THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE SEVENTH.

1851.

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.

MDCCCLI.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

ELECTED FEBRUARY 1851.

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Prof. A. C. Ramsay.
W. W. Smyth, Esq., M.A.

Assistant-Secretary, Curator, and Librarian.

T. Rupert Jones, Esq.

TABLE OF CONTENTS.

ORIGINAL COMMUNICATIONS.

LIST OF THE FOSSILS FIGURED AND DESCRIBED IN THIS VOLUME.

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

Name of Species.	Formation.	Locality.	Page.
	Mollusca. (35.)		
Antinomia angulata (Catul.). Woodcut, f. 4, 3.	Upper Epiolitic limestone.	Venetian Alps	75
—— angusta (Catul.). Woodcut, f. 4, 4.	Upper Epiolitic limestone.	Venetian Alps	75
—— deltoidea (Catul.). Woodcut, f. 3, 2.	Neocomian limestone.	Venetian Alps	75
—— dilatata (Catul.). Woodcut, f. 4, 5.	Upper Epiolitic limestone.	Venetian Alps	75
—— diphya (Catul.). Woodcut, f. 3, 1	Neocomian limestone.	Venetian Alps	75
Atrypa hemisphærica, var. Pl. ix. f. 12	Silurian.........	Ayrshire	171
Hemithyris angustifrons. Pl. ix. f. 10	Silurian.........	Ayrshire	171
Orbicula? crassa. Woodcut (p. 151) & Pl. x. f. 3, 4.	Silurian.........	Ayrshire	175
Orthis calligramma, var. virgata. Pl. viii. f. 4.	Silurian.........	Ayrshire	170
—— confinis. Pl. viii. f. 5	Silurian.........	Ayrshire	170
—— reversa. Pl. ix. f. 13	Silurian.........	Ayrshire	171
Terebratula cuneata. Pl. ix. f. 11 ...	Silurian.........	Ayrshire	172
——, *sp.* Pl. viii. f. 3	Silurian.........	Ayrshire	170
Cyrena arata. Pl. v. f. 6...............	Oolite	Isle of Skye	112
—— *Cunninghamii.* Pl. v. f. 9	Oolite	Isle of Skye	112
—— *Jamesonii.* Pl. v. f. 7, 8.........	Oolite	Isle of Skye	111
—— *Maccullochii.* Pl. v. f. 10	Oolite	Isle of Skye	112
Ostrea Hebridica. Pl. v. f. 4	Oolite	Isle of Skye	110
Perna Murchisonii. Pl. v. f. 1	Oolite	Isle of Skye	111
Pleurorhynchus dipterus, var. *rhomboideus.* Pl. viii. f. 6.	Silurian.........	Ayrshire	175
Potamomya? Sedgwickii. Pl. v. f. 3...	Oolite	Isle of Skye	113
—— ? *Sowerbii.* Pl. v. f. 2	Oolite	Isle of Skye	112
Trigonia tripartita. Pl. v. f. 11	Oolite	Isle of Skye	111
Unio? Staffinensis. Pl. v. f. 5	Oolite	Isle of Skye	111
Bellerophon acutus. Pl. ix. f. 18	Silurian.........	Ayrshire	172
Macleurea, sp. Pl. viii. f. 7............	Silurian.........	Ayrshire	176
Neritina Staffinensis. Pl. v. f. 13	Oolite	Isle of Skye	110
Rissoa (Hydrobia) conulus. Pl. v. f. 12	Oolite	Isle of Skye	110
Trochus Moorei? Pl. ix. f. 14.........	Silurian.........	Ayrshire	171
Turbo, sp. Pl. ix. f. 15	Silurian.........	Ayrshire	171
Nidulites favus. Pl. ix. f. 16, 17......	Silurian.........	Ayrshire	174
Cyrtoceras, sp. Pl. x. f. 8	Silurian.........	Ayrshire	173
Orthoceras Barrandei. Pl. ix. f. 19..	Silurian.........	Ayrshire	177
—— politum. Pl. x. f. 5, 6............	Silurian.........	Ayrshire	172
—— vaginatum? Pl. x. f. 7	Silurian.........	Ayrshire	177
	Pisces. (2.)		
Cochliodus? sp. Woodcut	Carboniferous limestone?	Gloucestershire ...	266
Lepidotus Deccanensis. Pl. xv.	Oolite	Deccan, E. India ..	273

EXPLANATION OF THE PLATES.

ERRATA.

Page xlviii. line 7 from top, *for* older *read* newer.
— xlviii. — 8 from top, *for* newer *read* older.
— liii. — 2 from top, *for* north-west *read* south-east.
— 4, — 22 from bottom, *for* more *read* now.
— 60, — 8 from bottom, *for* Pl. I. fig. 5 *read* Pl. I. fig. 6.
— 61, — 22 from top, *for* Pl. I. fig. 6 *read* Pl. I. fig. 5.
— 65, — 11 from top, for *G. Becki* read *G. Nicoli.*
— 65, — 12 from top, for *G. Nicoli* read *G. Becki.*
— 65, — 19 from top, for *G. bicornis?* read *G. rectangularis.*
— 76, — 14 from bottom, *for* in contact with *read* contiguous to.
— 77, — 25 from top, *before* mineral waters *insert* principal.
— 77, — 10 from bottom, *for* south *read* east.
— 134, — 2 from bottom, *for* fourteen *read* one hundred and eighty.
— 143, — 25 from bottom, *for* limestone *read* flagstone.
— 149, in description of woodcut, *for* shelly limestones with pebble beds *read* shelly sandstones with pebble beds.
— 212, line 14 from top, *for* commencement *read* close.
— 212, — 15 from top, *for* close *read* commencement.

Directions to the Binder.

The Binder is directed to place opposite page 15, Part I. the loose slip relating to the Sichon Fossils; and at page 143 the loose slip issued with No. 28.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 21, 1851.

REPORT OF THE COUNCIL.

In laying before the Geological Society a Report of the occurrences of the past year, the Council congratulate its Members on the general prosperity of their affairs. Their numbers have sustained a small diminution. During the past year 14 Fellows have been elected, in addition to 2 who have paid their admission-fees in the last year, although elected in the previous, making an increase of 16. On the other hand, the Society has lost 12 Fellows by death, and 11 by resignation, in all 23. Deducting from this number the 16 new Fellows, the decrease in the number of Ordinary Fellows is 7. The Society has lost by deaths 2 Honorary Members and 6 Foreign Members,—while 2 Foreign Members have been elected, occasioning a loss of 6; which, added to the loss of 7 Ordinary Fellows, reduces the number of the Society from 888 at the close of 1849, to 875 at the close of 1850.

The expenditure during the past year has exceeded the income by £120 10*s.* 6*d.* This has arisen from the unusual expenditure on the Library, and on the Quarterly Journal. It will be in the recollection of the Society, that during the years 1848 and 1849 the income had exceeded the expenditure by the sum of £289 0*s.* 8*d.*: the Council judged that no mode of expending a portion of this balance could be devised more favourable to the interests of the Society, or more in unison with their wishes, than in the purchase of books. They have accordingly expended £84 towards this object, and the list of the more important works, printed in the Report of the Library Committee, will show the value of this accession to the Library.

The sum expended on the Journal has also exceeded the average of past years, in consequence of the number of engraved plates required for the illustration of papers read before the Society being three times as great as in 1849. After deducting this extraordinary expenditure, there is still a balance in favour of the Society upon the last three years of £168 10*s.* 2*d.*

The number of compounders at the close of 1849 was 131, and at the close of 1850, 132; two having died, and three Fellows having compounded during the year, whose compositions have been invested in the Funds. The total amount received from these 132 compounders is £4158. The amount of Stock held at the close of 1849 was £3597 10*s.* 5*d.*, and at the close of 1850 £3695 3*s.* 5*d.*; the estimated value of which (Consols being at 96) is £3547.

The Council have to announce the completion of Vol. VI. of the Journal, and the publication of the first part of Vol. VII.

The Council, having repeatedly received applications from Foreign Scientific Bodies to receive their publications in exchange for those of this Society, have come to the resolution of adopting this principle of exchange; with the view both of diffusing abroad a knowledge of the progress of our science in England, and of acquiring valuable foreign works which could not otherwise be procured. The following Societies have already entered into this amicable arrangement:—

The Linnean Society of Normandy.
The Society of Agriculture and Science of Puy en Velay.
The Linnean Society of Bordeaux.
The Academy of Sciences of Lyons.
The Academy of Sciences of Madrid.
The Academy of Science of Philadelphia.
The Chemical Society of London.

Mr. Nicol having accepted the appointment of Professor of Geology in Queen's College, Cork, the Society has lost the services of that zealous officer. From several deserving candidates, the Council selected for recommendation Mr. Rupert Jones, for the offices of Assistant Secretary, Librarian, and Curator of the Museum; and this recommendation was confirmed by a General Meeting.

When the Council determined in 1845 that Palladium was the fittest substance to employ for the Wollaston Medal, Mr. Percival Norton Johnson, F.G.S., expressed a wish to present Palladium for that object, as a token of his grateful esteem for Dr. Wollaston. The Palladium then presented being at length exhausted, Mr. Johnson has again most handsomely offered to present the Society with the requisite metal. The Council have thereupon expressed their thanks to Mr. Johnson for this renewed proof of his regard for the Society, and his esteem for his late friend Dr. Wollaston; and have further directed, that the name of Mr. P. N. Johnson be added to the Contributors to the Donation Fund.

The Council have ordered that a Bronze copy of the Wollaston Medal be presented to the Trustees of the British Museum.

The arrangement of the Foreign Collection, the commencement of which was announced in the last Annual Report, has been continued during the past year by a Committee consisting of Mr. Bowerbank, Mr. Pratt, Mr. Sharpe, and Mr. S. Wood. Such specimens as were not required for the Collections have been set aside, and divided into sets, for presentation to other scientific bodies. Of those Societies which have applied for duplicate specimens, the Council have preferred the claims of such as apply their collections to educational purposes; conceiving that in so doing they best promote a taste for geological investigation. They have accordingly directed sets of rocks and minerals to be presented to the Societies enumerated in the Report of the Museum Committee.

The Council have also to announce, that in consideration of the long and faithful services of Mr. Charles Nichols, they have resolved that his salary henceforth, dating from the last quarter, shall be £120 per annum.

In conclusion they have to inform the Society that they have awarded the Wollaston Palladium Medal for this year to Professor Adam Sedgwick for his important and original researches in Geology, more especially for his Memoirs inserted in the Transactions of the Geological Society of London and Philosophical Society of Cambridge, developing the structure of the British Isles, the Alps, and Rhenish provinces; and that they have granted the balance of the proceeds of the Wollaston Donation Fund to M. Joachim Barrande, for the purpose of assisting him in the publication of his valuable work on the Silurian System and Fossils of Bohemia.

Report of the Museum and Library Committee.

The Committee beg leave to present the following Report on the state of the Museum and Library, and on the progress made in those departments during the past year.

Museum.

British Collection.—This most important part of the Society's collection continues in the excellent order in which it was left by Mr. Lonsdale and his successors, which is such as to enable any visitor consulting it to find the object he is in search of without waste of time. Mr. Jones has placed in their proper drawers the specimens which have been presented to the Society during the year, and also some good British fossils which were found in examining the accumulation of specimens which had formed in the crypts. The drawers are nearly all full, but it will be easy to find room for the specimens likely to be presented during several years, by discarding many of the inorganic specimens, which are of little interest in the present state of science.

Foreign Collection.—The Committee reappointed by the Council to arrange this department have devoted such time to the work as their other occupations permitted: they have placed in drawers, arranged in the order adopted, all the specimens worth retaining, brought from the crypts from time to time. As these repeated additions frequently deranged the parts of the collection previously arranged, the time consumed has been very great, in consequence of which there still remain some few things to be worked into their places in the Foreign Museum. But when it is remembered that in the course of the last two years the Committee have had to examine the contents of nearly 300 boxes, and have sorted about 10 tons of specimens which had been suffered to accumulate downstairs, they will not be charged with negligence in the task committed to them.

The arrangement of the specimens of rocks retained in the Foreign Museum is quite complete, with the exception of the cabinet containing the series destined for mineralogical study, which has not yet received the additions intended to be made to it of specimens set aside for this purpose.

In the department of European Organic Remains, the Tertiary and Secondary series have been brought into very good order ; but the Palæozoic series requires examination, and will be improved by having the duplicates weeded out.

The Asiatic, Australian, African, and American collections are all placed in drawers, which are nearly in the order they are finally to occupy ; but these drawers contain many duplicates which should be removed to leave room for future additions.

There remain downstairs some boxes belonging to different Fellows of the Society, and two interesting collections, the destination of which has still to be considered, the one of mammalian and reptilian bones, the other of fossil woods, both from various countries : the large size of these specimens has prevented the Committee from arranging them in the Foreign Museum.

The British Collection being in excellent order, the Committee suggest that such time as the Assistant Secretary may have to give to the Museum be principally devoted for the present to the Foreign Collection.

Duplicates.—The Committee carefully examined the whole of the mass of duplicates and unarranged specimens which were contained in the crypts, and after placing in the Museum such as were required there, and discarding all that were utterly valueless, set apart the rest conveniently arranged for the decision of the Council. Of these, the Council has already presented collections to the following Institutions, viz. :—

Museum of Practical Geology, a collection of igneous rocks;
Military Academy at Woolwich, a collection of minerals and rocks ;
École des Mines, Paris, a large collection of British fossils;
To each of the Queen's Colleges, at Cork, Belfast, and Galway, a set of minerals;
Cirencester Agricultural College, a set of minerals ;
The Free Kirk College at Edinburgh, a set of minerals ;
Ipswich Museum, a set of minerals;
Mr. Robert Brown, specimens of fossil wood;

and Dr. Fitton has received back the duplicates which remained from a collection of fossils formerly presented by him, after all the specimens required for the Society's collection had been placed in the Museum.

Library.

Great additions have been made to the Library during the year, arising from presents to the Society, from purchases made by order of the Council, and especially from the Transactions and Journals of Foreign Societies received in exchange for the Society's Publications. The plan of exchanging Publications with Societies abroad has produced such excellent results, that the Committee hope it will be continued. A list of the principal additions is added to the Report.

Owing to the large additions, it has been necessary to re-arrange and re-label the Books, which is at present in progress.

Signed, CHARLES LYELL.
DANIEL SHARPE.
SEARLES WOOD.
JOHN MORRIS.

Somerset House, 3rd February, 1851.

Some of the most important of the Books purchased by order of Council.

Roemer's Versteinerungen des Norddeutschen Kreidegebirges.
Miller's Old Red Sandstone.
—— Footprints of the Creator.
Linné's Systema Naturæ, 12th Edit.
Bronn's Geschichte der Natur.
Goeppert's Genera Plantarum Fossilium.
Philippi's Enumeratio Molluscorum Siciliæ.
Annals and Magazine of Natural History, Last Series.
Forbes and Hanley's British Mollusca.
Agassiz' Études sur les Mollusques.
—— Monographies sur les Échinodermes.
Dunker and Meyer's Palæontographica.
Münster's Beiträge zur Petrefacten-Kunde.
Mantell's Medals of Creation.
Humboldt's Aspects of Nature.
Dunker and Koch's Beiträge zur Kenntniss des Norddeutschen Oolithgebildes.
Geinitz' Characteristik der Schichten und Petrefacten des sächsisch böhmischen.
Unger's Synopsis Fossilium Plantarum.
Corda's Beiträge zur Flora der Vorwelt.
Heer's Insecten-fauna der Tertiärgebilde von Œningen und von Radoboj.

Comparative Statement of the Number of the Society at the close of the years 1849 *and* 1850.

	Dec. 31, 1849.		Dec. 31, 1850.	
Compounders		131		132
Residents		228		215
Non-residents		456		461
		815		808
Honorary Members	19		17	
Foreign Members	50		46	
Personages of Royal Blood	4	73	4	67
		888		875

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1849 *and* 1850.

Number of Compounders, Residents and Non-residents, December 31, 1849				815
Add, Fellows elected during former years, and paid in 1850	Residents	2		
			2	
Fellows elected, and paid, during 1850	Residents	8		
	Non-residents	6		
			14	
				16
				831
Deduct, Compounders deceased			2	
Residents			4	
Non-residents			6	
Resigned			11	
				23
Total number of Fellows, 31st Dec. 1850, as above				808
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1849				73
Add, Foreign Members elected in 1850				2
				75
Deduct, Foreign Members deceased			5	
Honorary Members			2	
Foreign Member removed			1	
				8
			As above	67

Number of Fellows liable to Annual Contribution at the close of 1850, with the Alterations during the year.

Number at the close of 1849		228
Add, Elected in former years, and paid in 1850		2
Elected and paid in 1850		8
Non-residents who became Resident		1
		239
Deduct, Deceased	4	
Resigned	11	
Compounded	3	
Became Non-resident	6	
		24
As above		215

DECEASED FELLOWS.

Compounders (2).

Thomas Cabbell, Esq. | Sir Robert Peel, Bart.

Residents (4).

Thomas Bigge, Esq.
Thomas Colbeck, Esq.
Henry F. Hallam, Esq.
James Smith, Esq.

Non-residents (6).

George C. Fox, Esq.
George Leake, Esq.
William P. Taunton, Esq.
James Thomson, Esq.
Charles H. Wilkinson, M.D.
Rev. David Williams.

Honorary Members (2).

Thomas Fenwick, Esq. | Major Nesbitt.

Foreign Members (5).

Prof. H. D. de Blainville.
Marquis de Drée.
M. F. Dubois de Montpéreux.
M. François J. Lainé.
Lawrence Pansner, M.D.

The following Persons were elected Fellows during the year 1850.

January 23rd.—Samuel Clegg, jun., Esq., Putney; F. C. S. Roper, Esq., Clapton Square, Hackney; and J. O. H. Matthews, Esq., Church Street, Toronto.

February 6th.—Lieut.-Col. J. A. Lloyd, Mauritius; and William Pengelly, Esq., Orchard Terrace, Torquay.

March 13th.—Henry H. Vivian, Esq., Singleton House, Swansea; and Henry Smith, Esq., Parliament Street.

—— 27th.—Henry C. Sorby, Esq., Woodbourn, Sheffield.

April 10th.—William Murray, Esq., Monkland House, Lanarkshire.

—— 24th.—Douglas D. Heath, Esq., Berners Street, and Kitlands, Dorking.

May 8th.—Lord Alfred Churchill, Wilton Terrace.

—— 22nd.—The Hon. G. S. Gough, Grenadier Guards, Upper Brook Street.

June 5th.—His Grace the Duke of Argyll, Inverary Castle, Argyllshire.

November 20th.—George Edward Gavey, Esq., Chipping Campden, Gloucestershire; and Dr. James Macfadyen, Jamaica.

December 4th.—William Bennison, Esq., Twickenham; Thomas Rowlandson, Esq., Gibson Square, Islington; and Henry W. Taylor, Esq., Brunswick Place, Brixton Hill.

The following Persons were elected Foreign Members.

Nov. 20th.—Professor B. Studer, Berne; and Herr Hermann Von Meyer, Frankfort-on-Maine.

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

British Specimens.

Specimens of *Lichas Bucklandi*, on Wenlock Limestone from Dudley; presented by T. W. Fletcher, Esq., F.G.S.

Specimen of Silicified Coral from Tisbury, Wilts; presented by J. F. Spencer, Esq.

Specimens of Mollusca and Fossil Wood from the Plastic Clay Series of Woolwich; presented by the Rev. H. M. De la Condamine.

Foreign Specimens.

Specimen of Igneous Rock with Concretions, from Geelong, Melbourne, New South Wales; presented by Lieut. W. H. Breton, R.N., F.G.S.

Specimens of Fossils from Portugal; presented by D. Sharpe, Esq., F.G.S.

Charts and Maps.

The Charts, &c., published by the Admiralty during the year 1849; presented by Rear-Admiral Sir Francis Beaufort, by direction of the Lords Commissioners of the Admiralty.

Map and Four Sheets of Sections of the Damoodah Coal Field, by D. H. Williams; presented by the Directors of the Honourable East India Company.

Charts, Plans, &c., published by the Dépôt de la Marine; presented by M. le Directeur-Général du Dépôt de la Marine.

Tableau d'Assemblage des Six Feuilles de la Carte Géologique de la France, par MM. Dufrénoy et Élie de Beaumont; presented by M. Élie de Beaumont, For. M.G.S.

Johnston's Plan of the City of Edinburgh; presented by Messrs. W. and A. K. Johnston.

Environs of Oxford, enlarged from the Ordnance Map; the Geological Survey and Sections, by the Rev. A. D. Stacpoole, M.A.; presented by the Author.

Carte von dem Kaukasischen Isthmus und von Armenien, von Prof. Dr. Karl Koch; presented by the Publisher, Herr V. von Dietrich Reimer.

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.

Academy of Sciences of Dijon.
Academy of Sciences of Paris.
Admiralty, The Right Hon. the Commissioners of the.
Agassiz, M. Louis, For. M.G.S.
American Academy of Arts and Sciences.
American Philosophical Society.
Architect and Building Gazette, Editor of.
Athenæum, Editor of.

Barrande, M. Joachim.
Beardmore, N., Esq., F.G.S.
Beke, C. T., Esq.
Bellardi, Signor L.
Béron, M. P.
Bianconi, Prof. J. J.
Bicheno, J. E., Esq., F.G.S.
Brayley, E. W., jun., Esq., F.G.S.
Brent, G. S., Esq.
Breslau, Akademie der Naturforscher zu.
Breton, Lieut. W. H., R.N., F.G.S.
British Museum, Trustees of the.
British Association for the Advancement of Science.
Buckland, Mrs.

Calcutta Library, Curators of.
Cambridge Philosophical Society
Chantereaux, M. Bouchard.
Chemical Society of London.
Condamine, Rev. H. M. de la.
Conrad, T. A., Esq.

Daubeny, Prof., M.D., F.G.S.
Davidson, Thomas, Esq.
Deane, J., M.D.
Dechen, H. von.
Delesse, M. Achille.
Dépôt Général de la Marine de France.
D'Orbigny, M. Alcide, For. M.G.S.
Dumont, Prof. A. H., For. Mem. G.S.

East India Company, Hon.
Egerton, Sir Philip G., Bart., M.P., F.G.S.
Élie de Beaumont, M. L., For. Mem. G.S.
English, H., Esq.

Faraday, M., Esq., D.C.L., F.G.S.
Favre, M. Alphonse.

Fletcher, T. W., Esq., F.G.S.
Fournet, M. J.

Geological Institute of Vienna.
Geological Society of Dublin.
Geological Society of France.
Geological Survey, Director-General of the.
Gibbes, R. W., M.D.
Glasgow Philosophical Society.
Göppert, Prof.
Gray, Rev. J. E.

Haidinger, Herr W.
Halle Society of Natural Sciences.
Hamburg Society of Natural Sciences.
Hartmann, Herr C.
Hincks, Rev. T., LL.D., Hon. Mem. G.S.
Hogg, John, Esq.
Hombres-Firmas, M. Le Baron de.
Homersham, S. C., Esq.
Hopkins, Prof. Wm., F.G.S.
Horner, L., Esq., F.G.S.
Horticultural Society.
Hutton, Captain Thomas, F.G.S.

Indian Archipelago Journal, Editor of,

Jackson, C. T., Esq.
Johnston, Messrs. W. and A. K.
Jones, Capt. T., R.N., F.G.S.
Jones, T. Rupert, Esq.
Jukes, J. B., Esq., F.G.S.

Koch, Prof. Dr. Karl.
Koninck, L. de, M.D.

Leonhard, Dr. G.
Les Alpes, Journal des Sciences, &c., Editor of.
Linnean Society.
Logan, J. R., Esq., F.G.S.
Lubbock, Sir J. W., Bart., F.G.S.
Lyceum of Natural History, New York.
Lyell, Sir Charles, Pres. G.S.

Mac Adam, J., Esq.
Mantell, G. A., LL.D., F.G.S.
Martin, John, Esq.
Milano, Imp. R. Instituto Lombardo di Scienze.
Moore, J. C., Esq., Sec. G.S.
Murchison, Sir R. I., V.P.G.S.
Mylne, R. W., Esq., F.G.S.

Nesbit, J. C., Esq., F.G.S.

Paris, L'École des Mines.
Paris, Muséum d'Histoire Naturelle de.
Perrey, Prof. A.
Philadelphia Academy of Natural Sciences.
Prestwich, J., jun., Esq., F.G.S.

Reeve and Co., Messrs.
Rennie, G., Esq., F.G.S.
Rivière, M. A.
Royal Academy of Belgium.
Royal Academy of Berlin.
Royal Academy of Munich.
Royal Academy of Stockholm.
Royal Academy of Turin.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Astronomical Society.
Royal College of Surgeons.
Royal Cornwall Polytechnic Society.
Royal Geographical Society.
Royal Geological Society of Cornwall.
Royal Institution.
Royal Institution of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Rütimeyer, Dr. L.

Sabine, Lieut.-Col., F.G.S.
Saint-Claire Deville, M. Ch.
Scarborough Philosophical Society.
Schlagintweit, Dr. H. and Dr. A.
Sedgwick, Rev. Prof., F.G.S.
Sharpe, D., Esq., F.G.S.

Shropshire and N. Wales Natural History Society.
Silliman, Prof., M.D., For. Mem. G.S.
Société d'Agriculture, Science, Arts, et Commerce, du Puy.
Société Hollandaise des Sciences à Haarlem.
Société Impériale de Naturalistes de Moscou.
Société Linnéenne de Bordeaux.
Société Linnéenne de Normandie
Society of Arts.
Spencer, J. F., Esq.
Stacpoole, Rev. A. D., M.A.
St. Petersburg Imperial Academy.

Taylor, R., Esq., F.G.S.
Taylor, Walton, and Maberly, Messrs.
Tchihatchef, M. P. de.
Tennant, Prof., F.G.S.
Thurman, M. Jules.
Trimmer, Joshua, Esq., F.G.S.

Wild, J. J., Esq.
Williams and Norgate, Messrs.
Wisbaden Natural Hist. Society.

Zoological Society.

List of PAPERS *read since the last Anniversary Meeting, February* 15*th*, 1850.

1850.

Feb. 27th.—On the Strata and the Organic Remains exposed in the Cuttings of the Branch Railway from the Great Western Line near Chippenham, through Trowbridge, to Westbury in Wiltshire, by R. N. Mantell, Esq.; communicated by G. A. Mantell, LL.D., F.G.S.

———— On the Dinornis and other Birds, and the Fossils and Rock-specimens from New Zealand, by G. A. Mantell, LL.D., F.G.S.

March 13th.—Report on the discovery of Coal near Erzeroom (forwarded from the Foreign Office, by order of Viscount Palmerston).

———— On the Metamorphic Rocks of Eastern Nova Scotia, by J. W. Dawson, Esq.; communicated by the President.

———— On the Structure of the Crystalline Rocks of the Andes and their Cleavage Planes, by Evan Hopkins, Esq., F.G.S.

March 27th.—On the Vents of Hot Vapour in Tuscany, and their Relations to Ancient Lines of Fracture and Eruption, by Sir R. I. Murchison, V.P.G.S.

April 10th.—On the Discovery, by Professor Lepsius, of Sculptured Marks on Rocks in the Nile Valley in Nubia, indicating that within the Historical Period the River flowed at a higher Level than in Modern Times, by Leonard Horner, Esq., F.G.S.

April 24th.—On the Boulder Clay of Wick, by John Cleghorn, Esq.; communicated by the President.

———— On the occurrence of Marine Shells in the Stratified beds below the Till, near Airdrie, by James Smith, Esq., of Jordan Hill, F.G.S.

———— On the New Red Sandstone of the Vale of the Nith, by Robert Harkness, Esq.; communicated by the President.

May 8th.—On the Geology of Spain, by Don J. Ezquerra del Bayo; communicated by Sir R. I. Murchison, V.P.G.S.

1850.

May 8th.—On some Fossil Plants from the Lower Lias, by Professor James Buckman, F.G.S.

———— On Dudley Trilobites, Part 2, by T. W. Fletcher, Esq., F.G.S.

May 22nd.—On a Gap in the Greywacke Formation of the Eastern Lammermuirs, filled with Old Red Sandstone Conglomerate, by W. Stevenson, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

———— On the Stratified Formations of the Venetian Alps, by Signor Achille de Zigno; communicated by Sir R. I. Murchison, V.P.G.S.

———— On the Limestone of Nash, near Presteign, South Wales, by J. E. Davis, Esq., F.G.S.

June 5th.—On British Fossil Lepadidæ, by Charles Darwin, Esq., F.G.S.

———— On the Diluvia and Valleys of the neighbourhood of Bath, by C. H. Weston, Esq., F.G.S.

———— On the Tertiary Strata and their Dislocations in the environs of Blackheath, by the Rev. H. M. De la Condamine; communicated by Sir H. T. De la Beche, V.P.G.S.

———— On the occurrence of a Freshwater Marl in the Fens of Cambridgeshire, by W. J. Hamilton, Esq., Sec.G.S.

June 19th.—On a Section of the Lower Greensand, at Seend, near Devizes, by William Cunnington, Esq.; communicated by Joseph Prestwich, jun., Esq., F.G.S.

———— On the Age and Position of the Fossiliferous Sands and Gravels of Farringdon, by R. A. C. Austen, Esq., F.G.S.

Nov. 6th.—On the Microscopical Structure of the Calcareous Grit of Yorkshire, by H. C. Sorby, Esq., F.G.S.

————On the Porphyry of Belgium, by Professor A. Delesse; communicated by the President.

———— On the Rose-coloured Syenite of Egypt, by Prof. A. Delesse; communicated by the President.

———— The Schistose Rocks of the Forez, in France, shown to be of Carboniferous Age, by Sir R. I. Murchison, V.P.G.S.

Nov. 20th.—Report on the occurrence of an Earthquake at Brussa (forwarded from the Foreign Office, by order of Viscount Palmerston).

———— Generalizations respecting the Erratic Tertiaries of Norfolk, by Joshua Trimmer, Esq., F.G.S.

———— On the Erratic Tertiaries of the Valley of Gaytonthorpe, by Joshua Trimmer, Esq., F.G.S.

———— On the Origin of the Soils of a part of Kent, by Joshua Trimmer, Esq., F.G.S.

———— Description of the Limestone Quarry at Linksfield, Elgin, by Capt. T. R. L. Brickenden, F.G.S.

Dec. 4th.—On the Geology of the Upper Punjaub and Peshaur, by Major N. Vicary; communicated by Sir R. I. Murchison, V.P.G.S.

———— On the Silurian Rocks of Dumfriesshire and Kirk-

1850.

cudbrightshire, by Robert Harkness, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

Dec. 4th.—Description of the Graptolites of the Black Shales of Dumfriesshire, by Robert Harkness, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

———— Report on the Coal Mines near Erzeroom (forwarded from the Foreign Office, by order of Viscount Palmerston).

Dec. 18th.—On the Epiolitic Rocks of the Venetian Alps, by Professor T. A. Catullo; communicated by Sir R. I. Murchison, V.P.G.S.

———— On the Origin of the Mineral Springs of Vichy, by Sir R. I. Murchison, V.P.G.S.

———— Report on a New Combustible Substance (Pungernite) discovered in Russia (forwarded from the Foreign Office, by order of Viscount Palmerston).

1851.

Jan. 8th.—On the Volcanic and Tertiary Strata of the Isle of Mull, by His Grace the Duke of Argyll; communicated by the President.

———— On the Estuary Beds and the Oxford Clay of Loch Staffin, in the Isle of Skye, by Prof. E. Forbes, V.P.G.S.

Jan. 22nd.—Memorandum respecting *Choristopetalum impar* and *Cyathophora* (?) *elegans*, by William Lonsdale, Esq., F.G.S.

———— On the Superficial Accumulations of the Coasts of the English Channel, and the Changes they indicate, by R. A. C. Austen, Esq., F.G.S.

———— On supposed Casts of Footsteps in the Wealden, by S. H. Beckles, Esq.; communicated by the President.

Feb. 5th.—On the Silurian Rocks of the South of Scotland, by Sir R. I. Murchison, V.P.G.S.

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

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

It was afterwards resolved,—

1. That the thanks of the Society be given to Sir Charles Lyell, retiring from the office of President.

2. That the thanks of the Society be given to Sir Henry Thomas De la Beche and Sir Roderick Impey Murchison, retiring from the office of Vice-President.

3. That the thanks of the Society be given to the Right Rev. the Bishop of Oxford, Charles Darwin, Esq., Rev. P. B. Brodie, Dr. Lyon Playfair, and L. L. B. Ibbetson, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

William Hopkins, Esq., M.A., F.R.S.

VICE-PRESIDENTS.

Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
D. Sharpe, Esq., F.R.S. and L.S.
Searles V. Wood, Esq.

SECRETARIES.

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

FOREIGN SECRETARY.

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

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

Prof. D. T. Ansted, M.A., F.R.S.
His Grace The Duke of Argyll, F.R.S.E.
R. A. C. Austen, Esq., B.A., F.R.S.
C. J. F. Bunbury, Esq., F.L.S.
Sir H. T. De la Beche, F.R.S. and L.S.
Sir P. Grey Egerton, Bart., M.P., F.R.S.
Earl of Enniskillen, D.C.L., F.R.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq.
William Hopkins, Esq., M.A., F.R.S.
Leonard Horner, Esq., F.R.S. L. and E.
Capt. Henry James, R.E.
Sir Charles Lyell, F.R.S. and L.S.
G. A. Mantell, LL.D., F.R.S. and L.S.
John C. Moore, Esq.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
John Lewis Prevost, Esq.
Prof. A. C. Ramsay.
D. Sharpe, Esq., F.R.S. and L.S.
W. W. Smyth, Esq., M.A.
S. V. Wood, Esq.

Trust Accounts.

Receipts.

	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1850, on the Wollaston Donation Fund	31	11	6			
Balance at Banker's, Geological Map Fund	20	10	0			
Total at Banker's, Jan 1st, 1850				52	1	6
Received on account of the Geological Map sold	19	0	0			
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31	11	6			
				50	11	6
				£102	13	0

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

J. S. BOWERBANK, DANIEL SHARPE, *Auditors.*

Jan. 29, 1851.

Payments.

	£	s.	d.
Award to Mr. John Morris	31	5	6
Cost of Engraving Palladium Medal awarded to Prof. Hopkins	0	6	0
Paid on account of Geological Map: Messrs. Lowry and Bone for 25 Copies	36	15	0
Balance at Banker's, Trust Account	34	6	6
	£102	13	0

Valuation *of the Society's Property; 31st December*, 1850.

Property.

	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. VI.				49	4	5
Due for Subscriptions				25	6	0
Balance in Banker's hands				430	3	1
Balance in Clerk's hands				21	13	9
Funded Property, 3695*l.* 3*s.* 5*d.* Consols				3547	0	0
Arrears of Admission Fees (considered good)	44	2	0			
Arrears of Contributions prior to 1850 (considered good)	9	9	0			
Arrears of Contributions of 1850	28	7	0			
				81	18	0
				£4155	5	3

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

Jan. 25, 1851. J. L. PREVOST, *Treasurer.*

Debts.

	£	s.	d.
Due to Messrs R. and J. E. Taylor, on Journal, Vol. VI.	58	4	3
Balance in favour of the Society	4097	1	0
	£4155	5	3

Income and Expenditure during the

INCOME.

	£	s.	d.	£	s.	d.
Outstanding, 1849 :						
Quarterly Journal, Vol. V. (Messrs. Longman & Co.) paid June 14th				50	15	9
Quarterly Journal, Vol. V. Author's corrections				17	5	0
Balance at Banker's, January 1, 1850	517	11	1			
Balance in Clerk's hands	19	18	2			
				537	9	3
Compositions received				94	10	0
Arrears of Admission Fees	12	12	0			
Arrears of Annual Contributions	22	1	0			
				34	13	0
Admission Fees of 1850				113	8	0
Annual Contributions of 1850				684	1	6
Dividends on 3 per cent. Consols				105	5	2
Sale of Transactions				39	4	9
Sale of Transactions in separate Memoirs				2	19	7
Sale of Proceedings				4	3	8
Journal, Vol. I., allowance on sale from the Publisher				0	15	0
Sale of Journal, Vol. II.				5	8	0
Sale of Journal, Vol. III.				6	16	6
Sale of Journal, Vol. IV.				9	4	6
Sale of Journal, Vol. V.				40	11	6
Sale of Journal, Vol. VI.				149	0	1
Sale of Library Catalogue				2	0	0
				£1897	11	3

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

DANIEL SHARPE, J. S. BOWERBANK, } *Auditors.*

Jan. 29, 1851.

Year ending December 31st, 1850.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Outstanding, 1849:						
Quarterly Journal, Vol. V. (Messrs. R. and J. E. Taylor) ..				42	2	6
Compositions invested				94	10	0
General Expenditure:						
Taxes	35	1	4			
Fire Insurance	3	0	0			
House Repairs	12	15	6			
Furniture Repairs	11	19	1			
New Furniture	18	1	9			
Fuel	33	5	0			
Light	26	8	4			
Miscellaneous House Expenses, including Postages	47	0	11			
Stationery	22	16	10			
Miscellaneous Printing	20	17	0			
Tea for Meetings	23	14	1			
				254	19	10
Salaries and Wages:						
Assistant Secretary and Curator	182	10	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	10	0	0			
Collector	22	3	9			
				427	17	9
Library				84	7	2
Museum........................				1	16	0
Diagrams at Meetings				15	19	0
Miscellaneous Scientific Expenses				4	3	5
Contributions of 1850 repaid				6	6	0
Publications:						
Transactions	34	6	4			
Transactions, separate Memoirs	0	12	7			
Journal, Vol. I., presentation Copies	2	9	6			
Journal, Vol. III.	0	9	9			
Journal, Vol. IV.	0	8	7			
Journal, Vol. V.	5	13	9			
Journal, Vol. VI.	467	12	3			
Proceedings	2	0	0			
				513	12	9
				1445	14	5
Balance at Banker's, Dec. 31, 1850....	430	3	1			
Balance in Clerk's hands	21	13	9			
				451	16	10
				£1897	11	3

Estimates *for the Year* 1851.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Account due by Messrs. Longman and Co. in June, on Journal, Vol. VI.				49	4	5
Due for Subscriptions on Quarterly Journal				25	6	0
Arrears (See Valuation-sheet)				81	18	0
Ordinary Income for 1851 estimated:						
Annual Contributions (210 Fellows)				661	10	0
Admission Fees:						
Residents (6)	37	16	0			
Non-residents (6)	63	0	0			
				100	16	0
Dividends on 3 per Cent. Consols				106	0	0
Sale of Transactions, Proceedings, Catalogue, &c.				45	0	0
Sale of Quarterly Journal				260	0	0
				£1329	14	5

J. L. PREVOST, Treasurer.

Jan. 25, 1851.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
Bill due to Messrs. R. and J. E. Taylor, on Journal, Vol. VI.				58	4	3
General Expenditure:						
Taxes	35	1	4			
Fire Insurance	3	0	0			
House Repairs	20	0	0			
Furniture Repairs	25	0	0			
New Furniture	15	0	0			
Fuel	33	0	0			
Light	26	0	0			
Miscellaneous House Expenses	47	0	0			
Stationery	20	0	0			
Miscellaneous Printing	30	0	0			
Tea for Meetings	24	0	0			
				278	1	4
Salaries and Wages:						
Assistant Secretary	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	10	10	0			
Collector	22	0	0			
				465	14	0
Library, Binding and Additions				30	0	0
Museum				6	0	0
Diagrams at Meetings				15	0	0
Miscellaneous Scientific Expenditure				4	0	0
Publications, Quarterly Journal				450	0	0
„ Transactions, &c.				20	0	0
				1326	19	7
Probable surplus of Income				2	14	10
				£1329	14	5

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

21st FEBRUARY, 1851.

Award of the Wollaston Medal and Donation Fund.

After the Reports of the Council had been read, the President, Sir Charles Lyell, delivered the Wollaston Palladium Medal to the Rev. Adam Sedgwick, M.A., Woodwardian Professor of Geology at the University of Cambridge, addressing him as follows:—

Professor Sedgwick,—The Council have informed the Society in their Report that they have awarded to you the Wollaston Medal of this year, for your original researches in developing the Geological Structure of the British Isles, the Alps, and the Rhenish Provinces. It was impossible for them to embody, in the brief terms of such an award, an analysis of your numerous and varied labours, and almost equally beyond my power to attempt to do the same in the few words which I can now offer on this subject. I may, however, refer to your memoirs on the Magnesian Limestone of the North of England, on the Trap Rocks of Durham and Cumberland, on the Fossiliferous Strata of the North of Scotland, and on the Isle of Arran,—your description of the Mountains of Cumberland and the adjoining Lake District, and of North Wales,—your essays on Slaty Cleavage,—the leading part you took in determining the true position and age of those strata of Devon and Cornwall which we now term Devonian, and lastly, your papers on the Alps and Rhenish Provinces.

In addition to these contributions to science, the Society has seen with pleasure the announcement of your work, now in the press, comprising a synoptical view of the Palæozoic Fauna of the North of England, Wales, and Scotland, so far as it is illustrated by specimens collected by yourself and presented by you to the Woodwardian Museum. When these fossils have been described by Prof. M^cCoy and figured by the skilful artist whom you employ, and when the geological bearing of each species is explained in your prefatory chapter, this volume will not fail to form an important addition to our scientific literature.

All, however, who hear me are aware, that by oral instruction given by you in Lectures at Cambridge and in conversational discussions in this room and elsewhere, as well as by the influence of such of your writings as are partly of a literary and partly of a scientific character, you have done nearly as much to forward the cause of Geology in England as by the memoirs of which I have attempted simply to enumerate the titles.

Professor Sedgwick replied,—

Mr. President,—On occasions like the present, it is not the custom, at the Royal Society, for one who receives a Medal to interrupt the proceedings of the day by any verbal expression of his thanks; with this Society the custom has, I believe, been different; and I trust that I may be permitted, before you begin your Anniversary Address, to say a few, a very few words, in order that I may convey to yourself, and the Members of the Council, my heartfelt thanks for the high honour you have now conferred upon me. Believe me, Gentlemen, very grateful for this honour, which will be remembered by me with sentiments of happiness and joy so long as I shall live. I do not wish to say, from any affected modesty, that I am altogether unworthy of this honour; to say this would be to impugn your judgement, which assuredly I have no right to do: and I am conscious of having, during many years of my life, toiled somewhat hard in the work of Geology, and therefore, in your service; I believe, however, that I owe much on this occasion to your friendship and personal regard. This, allow me to say, takes not from the sterling value of your award, but, on the contrary, adds to it and ennobles it, and makes it of incomparably more value to myself, than it could be were it unaccompanied by sentiments of personal regard and good will.

I could almost have wished that this award in my favour had been deferred to a future year, for my labours are still in progress, and a work is now in the press (alluded to, Mr. President, by yourself,) that would have appeared before this time, but for two painful accidents, which, during the greater part of the last two years, have cut me off from any continued efforts in the field of Geology. This work will contain a description by Professor M[c]Coy of all the new palæozoic fossils in the Cambridge collection, with a preliminary dissertation by myself on the grouping and classification of the older rocks of England. But, alas! Gentlemen, I dare not speak of the future with any confidence, for I know that my last three or four years have been unproductive, and I know that in a very little more than four years, should life be granted me, I shall reach that limit of man's age, beyond which his days are "but labour and sorrow." Let me rather then be grateful for the happiness I have enjoyed during the many years of active and intellectual communion I have been permitted to hold with the Members of this Society.

I am indeed reluctant to think that the Medal you have this day awarded me, is an honorary tribute to one who is at length retiring from your service. I wish not, and mean not to retire, for my task is yet undone; and if, through the goodness of Providence, my life be lengthened out in sound health of mind and body, I hope still to carry on my work and to be still your grateful friend and active fellow-labourer.

Whatever may befall myself during the few coming years of my life, believe, Gentlemen, in this heartfelt expression of my thanks; and believe me sincere in my wishes and aspirations for the great and continued progress of this Society, and for the happiness and honour of all its Members.

The President then addressed the Foreign Secretary as follows:—

Mr. Bunbury,—The Council have resolved that the Balance of the Proceeds of the Wollaston Donation Fund for the present year be awarded to M. Joachim Barrande, for the purpose of assisting him in the publication of his valuable work on the 'Silurian System and Fossils of Bohemia.'

The reputation of M. Barrande as a palæontologist was already established by his Memoirs on the Brachiopoda and Graptolites of

Bohemia, before we were made acquainted with that laborious undertaking the success of which the Council are now especially desirous to promote. As the public are not yet in possession of accurate information respecting this forthcoming work, I shall say a few words on its particular scope and bearing.

'The Silurian System of Bohemia,' a part of which is already in print, will consist of three quarto volumes, and will contain 160 plates, illustrating the state of the animal kingdom in the most ancient palæozoic period. Some of you have already seen fifty-two of the plates, devoted to the description of more than 200 species of Trilobites, with which the first volume is almost exclusively occupied, forming a splendid monograph of that curious tribe of extinct crustaceans. The second and third volumes will contain the Mollusca and other fossils, thirty plates of Cephalopods and Gasteropods being already executed. The faithful delineation of so many specimens, so perfectly preserved, will make the marine fauna of those remote times almost as well known to us as that of the tertiary seas.

In bringing together so vast a collection of materials, the author, a native of France, depended entirely on his own resources, and received no government assistance. On inquiring of him what was his method of collecting, he informed me that for ten consecutive years he had systematically pursued the same plan, which is so characteristic of his energy and perseverance, that the Society will not, I feel sure, deem it unworthy of notice. M. Barrande first made a preliminary survey of the region which he had resolved to explore, and having determined the relative position and outcrop of the various beds, engaged ten or twelve intelligent workmen, who were taught how to search for fossils, and provided with all the necessary tools, including magnifying-glasses. Under the superintendence of their employer, these men proceeded to open and work innumerable quarries, wherever there seemed to be a promise of obtaining organic remains, and solely for that object. They continued to labour uninterruptedly in this manner for ten years, and the following statement will give some idea of the rich harvest which they reaped. The Bohemian species of all classes of fossils previously described by Sternberg, Boeck, and Zenker, scarcely exceeded twenty in number, whereas M. Barrande during his investigation procured 1100 species from the same area,—probably the most numerous assemblage of palæozoic remains in the world, and even more valuable from the perfect state of their preservation than from their numbers.

The 1100 species may be divided into the different classes nearly as follows :—

Crustaceans, chiefly Trilobites	250	species.
Cephalopods	250	
Gasteropods and Pteropods	160	
Acephala	130	
Brachiopods	200	
Corals, &c. &c.	110	
	1100	

To a naturalist, it is not the least interesting circumstance attending these discoveries, to learn that all these fossils were obtained from a superficial area, not more extensive than one-sixtieth part of the Adriatic ; and they certainly show that the Silurian Fauna was not only as rich, but as much influenced by geographical conditions, or as far from being uniform throughout the globe, as that of any subsequent era. The preservation of the most delicate parts of many species extending even to their embryonic states, enabled the author to establish the fact of the metamorphosis of Trilobites in nineteen Bohemian species belonging to ten different genera. It has been shown that one species, called *Sao hirsuta*, presents itself under twenty different forms, out of which preceding naturalists had made eighteen species and ten genera, all now reduced to one species. It is at length therefore distinctly ascertained, and for the first time, that the development of the crustaceans followed the same laws in the palæozoic period as in our own times.

To the geologist it is satisfactory to know, that the successive groups of Bohemian fossils arranged stratigraphically, indicate a series of changes in organic life corresponding in chronological order to those of equivalent groups previously established for the classification of the palæozoic strata of Europe and North America. It appears also that the vertical range of certain species from the Lower to the Upper Silurian division is very great, apparently in cases where there has been a recurrence of similar geographical circumstances in the depth and mineral deposits of the ancient sea.

I need scarcely add, that no private individual of moderate fortune could accomplish such a task without great pecuniary outlay, and that the expense of publishing the results of his labours will entail still greater sacrifices. We hope, therefore, that this donation, which you will present to M. Barrande in our name, small as it is, may be an encouragement to him as an expression of our sympathy, and may make known to the public the high value we set on his forthcoming publication.

Mr. Bunbury said in reply,—

Sir,—As I am not personally acquainted with M. Barrande,—as, in fact, all my knowledge of him is derived from the interesting account of his researches which you have just given us,—I shall say no more than that I will take care, as far as lies in my power, that he shall receive the sum voted to him; and I have no doubt he will be gratified by this mark of the sense which the Geological Society entertains of the value of his labours. It is clear, from the facts you have stated, that the resources which the Wollaston Fund places at our disposal, cannot be better applied than in aiding the publication of M. Barrande's work; and we cannot but rejoice that we have it in our power to afford assistance and encouragement to a gentleman, who has exerted himself so zealously in the cause of Palæontology, and has rendered to it such important services.

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

ANNIVERSARY ADDRESS OF THE PRESIDENT,

SIR CHARLES LYELL.

GENTLEMEN,—The list of our Foreign Members has for many years been limited by the Council to the number of fifty, and death has deprived us since our last Anniversary of three of the most distinguished names which adorned this list, those of MM. Beudant, De Blainville, and Dubois de Montpéreux.

M. BEUDANT, a Member of the French Institute and Professor of Mineralogy in the College of France, is best known to us by his work on the Volcanic Mountains of Hungary, entitled 'Voyage Minéralogique et Géologique dans la Hongrie, pendant 1818,' published in 1822. It contains an excellent classification of the different varieties of trachyte, perlite, pitchstone, obsidian, and pumice, together with the opals and other siliceous minerals. His theory, that the lamination of trachyte and obsidian may have been due to the motion of the mass when in a fluid or semi-fluid state, has since been very generally adopted.

Among his early papers, we find a Memoir read to the Academy of Sciences in 1816, on the possibility of causing fluviatile mollusks to live in salt water, and marine mollusks to exist in fresh water. The mixture of marine and freshwater shells observed in a tertiary sandstone, called the grès de Beauchamp, near Paris, excited his curiosity on this subject, and he enjoyed facilities of making illustrative experiments and observations when appointed Professor in the College at Marseilles, near which the brackish water at the mouths of rivers entering the Mediterranean is inhabited both by fluviatile and marine species.

In 1817 M. Beudant published a paper on the Phenomena of

Crystallization, treating especially of the variety of forms assumed by the same mineral substance. He was also the author, in 1837, of two treatises on Mineralogy and Geology which are much esteemed; that on Geology having passed through five editions, and being adopted by the University of France as a text-book.

M. Marie-Henri Ducrotay de Blainville, Member of the Academy of Sciences in France, succeeded Lamarck as Professor of Natural History in Paris, and was afterwards chosen to replace Cuvier in the chair of Comparative Anatomy. His exertions in these departments of science were pursued uninterruptedly throughout half a century, and the catalogue of his memoirs and works given by Agassiz in his 'Bibliographia' amounts to no less a list than 150,—a list which might have been enlarged, as I learn from M. Constant Prevost, to 180, none of them without merit, and some, like his 'Manuel de Malacologie et Conchologie,' and his 'Osteography of the Vertebrate Classes,' being elaborate treatises which might well have cost a zoologist the labour of a life.

The 'Osteography,' published in 1839–40, comprised the extinct as well as living types of vertebrate animals, and is the most important of those contributions to Palæontology which gave him a title to be enrolled as one of our Foreign Members. M. de Blainville was himself a good artist, and the figures of the skulls and skeletons of nearly all the orders of mammalia which illustrate this treatise, are regarded by many eminent zoologists as the most accurate hitherto published.

In a controversy into which M. de Blainville entered respecting the place in the animal kingdom to be assigned to the celebrated fossils of the Stonesfield oolite, he opposed the previously declared opinion of Cuvier that they were true insectivorous mammals, and was inclined to believe in their reptilian character,—an opinion from which the most skilful comparative anatomists of Europe dissent; but while they decline to bow to his authority on this point, they do not dispute the general soundness of his views, still less the extraordinary range and profoundness of his knowledge of the animal kingdom.

"It was the great object of his life," says M. Prevost, "to establish in all his works, especially in his 'Osteology,' the doctrine that the whole series of organic beings was intimately related, the links of one great chain, ascending from the most simple of organisms to that which occupies the highest place; in other words, *from the Sponge to Man.* But while he endeavoured to refer all groups and every variety of animal form to one and the same plan, he never embraced the plausible hypothesis that each higher grade had been improved in the course of ages out of a lower one by transmutation;—on the contrary, he saw in the whole animal creation, one single operation, one great harmonious and divine idea, the various changes being neither due to chance nor to the influence of external circumstances, but being all the result of one and the same original conception*."

M. Frederic Dubois de Montpéreux was born in 1798 at Motiers, in the Canton of Neufchatel. After being teacher in a school at St. Gall, he became, at the age of twenty-one, tutor in the family of a Lithuanian landed proprietor, where he remained ten years. During this time he had access to an extensive library, and acquired a taste for scientific reading. This led him to turn his thoughts to the geology of Lithuania, on which subject he published some original observations in Karsten's Archives for 1830. He next became tutor to a young Polish nobleman with whom he passed two years in Berlin, making the acquaintance there of several of the most distinguished Professors in the University; and being encouraged by them, and especially by Baron von Buch, to continue his favourite line of research, he accordingly examined the tertiary strata of Volhynia and Podolia, and published a description of those regions in 1831, in a handsome quarto volume illustrated by figures of the fossil shells and a geological map.

About the same period he made a tour with his pupil through the valley of the Rhine, and afterwards to Denmark and Sweden. In 1831 he employed seven or eight months in exploring the banks of the Dnieper, not confining his attention to the geology of the Ukraine, but also collecting plants and discovering many new species, and extending his inquiries to matters of antiquarian and ethnological interest. His memoirs on these various subjects were printed in 1833 in Karsten's Archives and in Bronn's Jahrbuch.

* Discours Funèbre de M. C. Prevost, Mai 1850, Ann. des Sci.

In the spring of 1832, having realized a small independence, he set out alone on an expedition to explore the Crimea, the Caucasus, and the adjoining countries of Circassia, Georgia, and Armenia, including Mount Ararat. In this arduous undertaking he persevered for several years, patiently undergoing great bodily fatigue and privations while wandering through the territories of barbarous and uncivilized tribes, frequently unaccompanied even by a guide, and, although the Russian authorities gave him every assistance in their power as soon as they were made acquainted with the objects of his travels, often exposed to the most imminent personal danger. The fruits of nearly four years of observation were given to the scientific world in 1839 and 1842, in a splendid work in six volumes octavo, illustrated with plates and maps, entitled, 'Voyage autour du Caucase, en Colchide, Arménie, Georgie, et en Crimée.'

In these travels, M. Dubois first recognized the existence of strata of the age of the gault, upper greensand, and lower greensand in the Crimea, as well as portions of the upper and middle oolites of the Mediterranean type. He also traced the same formations together with the white chalk along the northern base of the Caucasus, as far as the river Kuban. In the same work he described the volcanic rocks of middle Armenia and Mount Ararat, recently the theatre of the labours of M. Abich, whom we have had the pleasure of seeing at several of our meetings during the past session. M. Abich, after spending seven years in the same countries, does ample justice to the accurate descriptions and enlightened views of the indefatigable pioneer, in whose footsteps he has so successfully trodden and whose discoveries he has so greatly enlarged.

In 1836 M. Dubois returned home to Switzerland, where he was appointed, in 1843, Professor of Archæology in the University of Neufchatel. He died on the 7th of May, 1850, at the age of fifty-two, an intermittent fever which he had caught in his travels having attacked him every spring with increasing intensity, slowly undermining his constitution, although his activity of mind and love of science continued undiminished to the last.

Among the ordinary Members whose loss we have to deplore since our last Anniversary, I have to mention the names of Sir Robert Peel, Lord Northampton, and Dr. Pye Smith.

Sir Robert Peel will always deserve to be gratefully remembered by Englishmen devoted to philosophical pursuits, as the first Prime Minister of this country, who, amidst the distractions of an active political career, made it a leading object of his thoughts to consider how the patronage of Government might be made available to the advancement of science and natural history. He was fully aware, as he stated to us, in an eloquent speech addressed to the Members of this Society at our Anniversary Meeting in 1849, that a Statesman who has such an end in view must be on his guard not to impair the personal independence of scientific men, while he endeavours to forward or reward their labours. He had no doubt reflected that the free expression of opinion had sometimes been fettered both in literature and science by the authority unduly usurped by official rank; and that the corporation spirit of endowed academies has sometimes been a source of division and jealousy among scientific men.

The education of Sir Robert Peel had not given him an early bias towards scientific studies, but, in proportion as his mind ripened and he had leisure for reading, he appreciated more and more their importance; and several of our Members who were among his personal friends well know that Geology engaged a full share of his attention. Yet few of us were prepared to find him capable of writing such a letter as that which has been published since his death, addressed to his relative the Dean of York, who had requested him to criticise his "System of Geology." In this remarkable letter we find Sir Robert zealously contending against the dogma that a single great convulsion might account for all the changes of the earth's crust. He begins by expressing his conviction of the truth "of the conclusions to which the most eminent men of all countries had gradually arrived after unremitting inquiry and profound reflection;" and then proceeds to argue that geological revolutions "had been the slow product, some of chemical, others of mechanical agencies." He instances a coal-field with its numerous strata of coal, all of vegetable origin and separated by beds of a different character, each distinguished from the other by some peculiarity of structure or organic remains, and he refers to the submergence of land and the formation upon it of new strata*. It is no small testimony to the vigour and clearness

* Colburn's New Monthly Mag., January 1851, p. 10.

of his understanding, that in sustaining a controversial argument, on a question so remote from his ordinary studies, he betrays in no single sentence those imperfect or unsound views so commonly apparent in the writings of men who derive their knowledge exclusively from books or conversation. It is scarcely necessary for me to remind you of the interest which Sir R. Peel took in the geological department of the Ordnance Survey of Great Britain, and the Museum of Practical Geology; the successful progress of which he watched with friendly care to the last. These, as well as his exertions to improve the Royal Observatory at Greenwich and the British Museum, show that he was by no means of opinion that the cause of science should be abandoned solely to voluntary associations of private individuals, or might not with propriety derive support from national grants of money.

I cannot conclude these remarks without availing myself of the opportunity of publicly acknowledging the annual grant of £1000 recently made by the First Lord of the Treasury, Lord John Russell, to the Royal Society, as a boon by which Geology, as well as other branches of science, cannot fail to be advanced, and in a manner entirely free from the objections sometimes urged against Government patronage. The expenditure of the money is entrusted to a Committee chosen by the Royal Society, and therefore placed wholly beyond the control of the minister or of any political influence. It is intended to aid scientific investigations, whether by the purchase of instruments, or by defraying the cost of experiments, or other expenses incurred. We, who have witnessed the fruits of a much smaller fund, placed in a similar manner at the disposal of the British Association, are justified in entertaining very sanguine expectations of the good which may accrue from such a grant and the stimulus which it may supply to original research.

The recent death of the Marquis of Northampton has deprived the Society of one of its oldest members, one who was highly respected for his talents and varied acquirements, and whose cheerful temper and kind manner rendered him universally popular. He was elected President of this Society in 1819, when Earl Compton, and during the first of the two years in which he filled this chair, he read a paper on the Geology of the South coast of Mull in the Hebrides.

In this memoir he gave a short account of the basaltic rocks of the island, and pointed out several places where the associated secondary formations contain ammonites and other fossils*.

In June 1838, Lord Northampton read to the Society a second paper, on those Foraminifera of the Chalk which are called Spirolites†. These original communications, and the fine collection of fossil remains and simple minerals which he accumulated at Castle Ashby, attest his love for Geology and Natural History, to the promotion of which he successfully devoted so large a portion of his life. During the ten years that he presided over the Royal Society, he continued frequently to attend our meetings and to cultivate the acquaintance and friendship of the most active of our members.

Dr. Pye Smith, who was for so many years a constant attendant at our meetings, was President of the Protestant Dissenting College at Homerton, where he was also teacher of Divinity. In this influential position he had an opportunity of imparting to a wide circle of pupils and admirers the interest which he felt in the new views brought to light from time to time by Geology. His work on "The Connection of Scripture and Geology," comprised a series of lectures delivered at Homerton College, in which he endeavoured to compensate for want of practical knowledge of the science by ample citations from the works of the best contemporary writers. He gave a description, in their own words, of many newly discovered facts, and a statement of the theories legitimately deduced from them, especially those most opposed to popular notions derived from a literal interpretation of the Hebrew cosmogony. He dwelt especially on the earth's high antiquity, the many changes which took place in the animate world antecedent to the creation of man, and the divergence both of animals and plants from many original centres instead of their multiplication from a single point. He also considered how far geological facts are reconcileable with the commonly received notions respecting a universal deluge, assumed to have happened only 4000 years before our time. He reminds his readers of the many texts of Scripture formerly adduced as hostile to established astronomical doctrines respecting the structure of the universe. With much good

* Geol. Trans. 1st Ser. vol. v. p. 369.

† See Proceedings of Geol. Soc. vol. ii. p. 685.

feeling, he declares it to be the duty of theologians to sympathise with scientific men in the doubts they entertain respecting many dogmas closely interwoven with the popular faith, and he insists on the inseparable relation of scientific and religious truth. All attempts to tamper with the evidence of physical facts, or to evade or set them aside, are denounced; and he exposes the repeated failure of various schemes for torturing the Hebrew text so as to make it speak the language of modern philosophy. He also alludes to the final abandonment, by every competent authority, of those theories which aimed at establishing a coincidence between geological epochs and the six days of creation. I am bound to confess that some of Dr. Pye Smith's own efforts to remove difficulties, by modifying the ordinary interpretations of the Hebrew text, are to my mind as unsuccessful as those of the greater number of his predecessors; but I feel convinced that if that voluminous class of books commonly called Scriptural Geologies, several of which have issued from the press even since our last anniversary, had been written with the same candour and fairness of spirit as that of Dr. Pye Smith, the public mind would have become ere this too enlightened to waste any more of its energies on controversies of this nature.

The amiable disposition and unaffected piety of Dr. Pye Smith secured to him the love and admiration of all who knew him; and it redounds to the honour of the congregational sect in which for nearly half a century he held a prominent station, that the work I have cited was generally well received, and when he retired from his academical office, the sum of £3000 was subscribed to provide for him an annuity during his life, and to endow after his death Divinity scholarships bearing his name in the new College now founded in St. John's Wood.

Gentlemen,—In my Anniversary Address of last year, I entered into an examination of the question, how far the leading discoveries of modern date tend to confirm or invalidate a doctrine which I had advocated twenty years before, in the first edition of my 'Principles of Geology,'—that the ancient changes of the animate and inanimate world, of which we find memorials in the earth's crust, may be similar both in kind and degree to those which are now in progress.

But in order to keep myself within due bounds, I confined my remarks on that occasion to the revolutions of the inorganic world, reserving for the present opportunity a comparison of the organic creation in ancient and modern times, and a consideration of the light thrown by Palæontology on the laws which govern the fluctuations of the living inhabitants of the globe.

It is not my intention to discuss now the popular theory, or rather hypothesis, which refers all the varieties of animal and vegetable forms and attributes, which we call species, to transmutation, or to changes taking place slowly in the course of ages, analogous to those which are brought about in a shorter time by fœtal development, or the growth and improvement of the embryo into the adult individual. These views I have uniformly opposed, for twenty years, and the favour which they have acquired of late, with the general public, in consequence of the eloquent pleading of the anonymous author of the 'Vestiges of Creation,' has been more than counterbalanced by the refutation which it has called forth in the works of Owen, Sedgwick, and Hugh Miller. But there is another doctrine adopted with more or less confidence by the eminent authorities above cited, and others of equal note, according to which a gradual development in the scale of being, both animal and vegetable, from the earliest periods to our own time, can be deduced from palæontological evidence. This theory is clearly stated in several parts of a luminous disquisition forming the Preface to a recently published 5th edition of Professor Sedgwick's Discourse on the Studies of Cambridge. "There are traces," he says, "among the old deposits of the earth of an organic progression among the successive forms of life. They are to be seen in the absence of mammalia in the older, and their very rare appearance in the newer secondary groups; in the diffusion of warm-blooded quadrupeds (frequently of unknown genera) in the older tertiary system, and in their great abundance (and frequently of known genera) in the upper portions of the same series; and lastly, in the recent appearance of man on the surface of the earth." (p. xliv.) "This historical development," continues the same author, "of the forms and functions of organic life during successive epochs seems to mark a gradual evolution of creative power, manifested by a gradual ascent towards a higher type of being."—Ibid. p. cliv. "But the elevation of the fauna of successive periods was not made by transmutation, but by creative additions; and it is by watching these additions that we get some insight into Nature's true historical progress, and learn that there was a time when Cephalopoda were the highest types of animal life, the primates of this world; that Fishes next took the lead, then Reptiles; and that during the secondary period they were anatomically raised far above any forms of the reptile class now living in the world. Mammals were added next, until Nature became what she now is, by the addition of Man."—Ibid. p. ccxvi.

From a recent work on Comparative Anatomy, by Professor Owen, distinguished by grand and comprehensive views in regard to the relations of different parts of the vertebrate creation to each other, I cite the following passage:—

"To what natural or secondary causes the orderly succession and progression of such organic phænomena may have been committed, we are as yet ignorant. But if, without derogation to the Divine Power, we may conceive the existence of such ministers and personify them by the term 'Nature,' we learn from the past history of our globe, that she had advanced with slow and stately steps, guided by the archetypal light amidst the wreck of worlds, from the first embodiment of the vertebrate idea, under its old ichthyic vestment, until it became arranged, in the glorious garb of the human form*."

I shall make one more extract, from the pages of Mr. Hugh Miller's 'Footprints of the Creator,' as it will place in a clear point of view the idea entertained by many geologists, that the successive development of the living inhabitants of the globe kept pace with a corresponding improvement in its habitable condition.

"It is of itself," he says, "an extraordinary fact, without reference to other considerations, that the order adopted by Cuvier in his 'Animal Kingdom,' as that in which the four great classes of vertebrate animals, when marshalled according to their rank and standing, naturally range, should be also that in which they occur in order of time. The brain which bears an average proportion to the spinal cord of not more than two to one, came first,—it is the brain of the fish; that which bears to the spinal cord an average proportion of two-and-a-half to one, succeeded it,—it is the brain of the reptile; then came the brain averaging as three to one,—it is that of the

* Owen on the Nature of Limbs, p. 86.

bird. Next in succession came the brain that averages as four to one,—it is that of the mammal; and last of all there appeared a brain that averages as twenty-three to one,—reasoning, calculating man had come upon the scene."

He then adds, "The record speaks also of development and progression in the province of insensate matter, a gradual improvement having taken place in the style and character of the dwelling-place of organized beings in the conditions of existence afforded by our common mansion-house, the earth. A partially consolidated planet, shaken by earthquakes more frequent and terrible than those of the historic ages, could be no proper home for a creature constituted like man, but may have suited the narrower capacities and more limited instinct of the fish and reptile. When the state of things became more fixed and stable, the higher mammals were introduced; and finally, after the great convulsions and catastrophes had ceased, or become extremely rare and partial, the reasoning brain was produced, that human mind which derives all its power from faith in the constancy of Nature's laws, which regulates all its actions on fixed phænomena;—a being which, if placed in circumstances where there was no certainty or stability in the order of the natural world, would become timid, superstitious, and more helpless and abject than even the inferior animals*."

If we then turn to the opinions entertained respecting the progress of the vegetable world from the earliest periods to the present, we find them ably set forth in an essay published last year by M. Adolphe Brongniart, on the botanical classification and geological distribution of the genera of fossil plants†. His generalizations are expressed with due philosophical caution, and he does not pretend to trace an exact historical series from the sea-weed to the Equisetum and Fern, or from these again to the Conifers and Cycads, and lastly from those families to the Palms and Oaks; but he nevertheless points out that the cryptogamic forms, especially the acrogens, predominate among the fossils of the primary (palæozoic) formations, the carboniferous especially, while the gymnosperms or the coniferous and cycadeous plants abound in all the strata from the Trias to the Wealden inclusive; and

* Footprints of the Creator, pp. 283, 286. Edinb. 1849.

† Tableau des genres de Végét. Foss., &c. Dict. Univ. d'Hist. Nat. Paris, 1849.

lastly, the more highly developed angiosperms, both monocotyledonous and dicotyledonous, do not become abundant until the tertiary period. It is a remarkable fact, as he justly observes, that the exogens, which comprise four-fifths of living plants,—a division to which all our native European trees, except the Coniferæ, belong, and which embraces all the Compositæ, Leguminosæ, Umbelliferæ, Cruciferæ, Heaths, and so many other families,—are wholly unrepresented by any fossils hitherto discovered in the primary and secondary formations from the Silurian to the oolitic inclusive. It is not till we arrive at the cretaceous period that they begin to appear, sparingly at first, and only playing a conspicuous part together with the palms and other endogens in the tertiary epoch.

To these writers, for whose judgement I have the greatest respect, I might add the testimony of other high authorities in support of similar views, but I shall content myself by concluding with a reference to Professor Bronn of Heidelberg, with whose 'Index Palæontologicus,' lately published, every geologist is, I trust, acquainted. From the ample data supplied by 24,000 species of fossil animals and plants enumerated in this elaborate catalogue, the author deduces not only the law of an increasing number and variety of species in the more modern, as compared to the more ancient formations, but also the successive introduction of the higher and more perfectly organized classes. I must not, however, lead you to suppose that every name of weight is ranged on one side of this controverted question, for in the communications made during the last year to the Academy of Sciences in Paris, I find a declaration by M. Constant Prevost, that he is not satisfied with the palæontological evidence in support of the doctrine of successive development, and a no less decided and more circumstantial statement by M. Alcide D'Orbigny of his reasons for dissenting from the same theory*.

Before I go into details, whether of fact or argument, on this question, I shall proceed, for the sake of enabling you the more readily to follow my train of reasoning, to make a brief preliminary statement of the principal points which I expect to establish in opposition to the theory of successive development.

* C. Prevost, Comptes Rendus, Sept. 1850, vol. xxxi. p. 461; and A. D'Orbigny, Ibid. June 1850, vol. xxx. p. 807.

First, in regard to fossil plants, it is natural that those less developed tribes which inhabit salt water, should be the oldest yet known in a fossil state, because the lowest strata which we have hitherto found, happen to be marine, although the contemporaneous Silurian land may very probably have been inhabited by plants more highly organized.

Secondly, the most ancient terrestrial flora with which we can be said to have any real acquaintance (the carboniferous) contains Coniferæ, which are by no means of the lowest grade in the phænogamous class, and, according to many botanists of high authority, Palms, which are as highly organized as any members of the vegetable creation.

Thirdly, in the secondary formations, from the triassic to the Purbeck inclusive, gymnosperms allied to Zamia and Cycas predominate; but with these are associated some monocotyledons or endogens, of species inferior to no phænogamous plants in the perfection or complexity of their organs.

Fourthly, in the strata from the cretaceous to the uppermost tertiary inclusive, all the principal classes of living plants occur, including the dicotyledonous angiosperms of Brongniart. During this vast lapse of time four or five complete changes of species took place, yet no step whatever was made in advance at any one of these periods by the addition of more highly organized plants.

Fifthly, in regard to the animal kingdom, the lowest Silurian strata contain highly developed representatives of the three great divisions of radiata, articulata, and mollusca, showing that the marine invertebrate animals were as perfect then as in the existing seas. They also comprise some indications of fish, the scarcity of which in a fossil state, as well as the absence of cetacea, does not appear inexplicable in the present imperfect state of our investigations, when we consider the corresponding rarity and sometimes the absence of the like remains observed in dredging the beds of existing seas.

Sixthly, the upper Silurian group contains amongst its fossil fish cestraciont sharks, than which no ichthyic type is more elevated.

Seventhly, in the carboniferous fauna there have been recently discovered several skeletons of reptiles of by no means a low or simple organization, and in the Permian there are saurians of as high a grade as any now existing, while the absence of terrestrial mammalia in the palæozoic rocks generally may admit of the same explanation as our ignorance of most of the insects and all the pulmoniferous mollusca, as well as of Helices and other land shells of the same era.

Eighthly, the fish and reptiles of the secondary rocks are as fully developed in their organization as those now living. The birds are represented by numerous foot-prints and coprolites in the Trias of New England, and by a few bones not yet generically determined, from Stonesfield and the English Wealden.

Ninthly, the land quadrupeds of the secondary period are limited to two genera, occurring in the inferior oolite of Stonesfield; the cetacea by one specimen from the Kimmeridge clay, the true position of which requires further inquiry, while an indication of another is afforded by a cetacean parasite in the chalk. But we have yet to learn whether in the secondary periods there was really a scarcity of mammalia, (such as may have arisen from an extraordinary predominance of reptiles, aquatic and terrestrial, discharging the same functions,) or whether it be simply apparent and referable to the small progress made as yet in collecting the remains of the inhabitants of the land and rivers, since we have hitherto discovered but few freshwater, and no land mollusca in rocks of the same age.

Tenthly, in regard to the palæontology of the tertiary periods, there seems every reason to believe that the orders of the mammalia were as well represented as now, and by species as highly organized; whether we turn to the Lower, or to the Middle, or to the Upper Eocene periods, or to the Miocene or Pliocene; so that during five or more changes, in this the highest class of vertebrata, not a single step was made in advance, tending to fill up the chasm which separates the most highly gifted of the inferior animals and man.

Eleventhly, the geological proofs that the human species was created after the zoological changes above enumerated are very strong. It even appears that man came later upon the earth than the larger proportion of the animals and plants which are now his contemporaries. Yet, for reasons above stated, had the date of his origin been earlier by several periods, the event would have constituted neither a greater nor a less innovation, on the previously established state of the animate world. In other words, there are no palæontological grounds for believing that the mammiferous fauna after being slowly developed for ages had just reached its culminating point, and made its nearest approach in organization, instinct, and other attributes, to the human type, when the progressive intellect and the rational and moral nature of man became for the first time connected with the terrestrial system.

The question then which I propose to test by the recent discoveries of geology and palæontology is this :—

First, whether the position of the fossil remains of plants in the earth's strata is such as to lead us to believe, that a cryptogamic flora preceded one consisting of flowering plants, and that the less perfect of the phanerogamic orders were created before the more perfect, and that the most varied and complex floras were last in historical succession.

Secondly, whether in like manner in the animal kingdom the cephalopod, fish, reptile, bird, and warm-blooded quadruped made their appearance upon the earth, one after the other,—the Orthoceras occurring in the oldest Silurian strata, the fish in the upper Silurian and Devonian, the reptile in the carboniferous, the bird in the triassic, the earliest quadrupedal mammifer in the oolitic, and the first quadrumanous mammal in the tertiary, and lastly, man in the post-tertiary era ;—a series, if established, which would seem almost irresistibly to lead us to the inference that a gradual advance towards a more perfect organization, or at least to an organization more and more resembling that of man, was intimately connected with geological chronology, the creation of the human species constituting the last term in a regular series of organic developments.

Our efforts to arrive at sound theoretical views on this important question may accelerate the future progress of discovery by directing the collectors of fossils to points where we stand most in need of information, or by stimulating another class of investigators to dredge the bottoms of lakes and seas, in order to teach us what are the laws now governing the imbedding of the remains of living plants and animals in newly-deposited sediment.

If we proceed then to consider the question first from a botanical point of view, we find that naturalists are by no means agreed as to the existence of an ascending scale of organization in the vegetable world corresponding to that which is very generally recognized in animals. "From the sponge to man," to borrow the words of De Blainville, there is a progressive chain of being, often broken, it is true, and imperfect, and in which some whole genera or families seem to have no natural place. But if we seek to classify plants according to a linear arrangement, ascending gradually from the lichen to the lily or the rose, we encounter incomparably greater difficulties. Yet the doctrine of a more highly-developed organization in the plants created at successive periods presupposes the admission of such a graduated scale.

There can, however, be no dispute that the cryptogamous plants are the least perfect, a class to which the marine vegetation almost entirely belongs. The sea, it is true, produces some flowering plants, such as Zostera and Caulinia, but they are among the least-developed of the phænogamous tribe. If then the oldest fossiliferous strata, the Silurian and the greater part of the Devonian, contain exclusively marine plants, we may attribute the low scale of their organization to the pelagic nature of the deposits, and our not having yet found the deltas of the then existing rivers into which we might expect land plants to have been drifted. Even the lacustrine genera of plants which are truly subaqueous, such as Chara and Potamogeton, are commonly regarded by botanists as holding an inferior rank to the great mass of the phænogamous vegetation of the land,—a circumstance not to be lost sight of, when we are considering the scale of organization in relation to geological epochs.

By far the greater number of the land plants hitherto referred to the Devonian strata on the continent of Europe, especially those in France, in the department of La Sarthe, and various parts of Brittany, have been lately shown (in 1850) by M. de Verneuil to belong to the carboniferous series. The same may be said of the species of Lepidodendron, Knorria, Calamite, Sagenaria, and other genera recently figured by M. F. A. Roemer from the formation called *Grauwacke à Posidonomyes* in the Hartz. We may treat therefore of the flora of the coal-measures as the first or oldest known to us, from which we can gain a true insight into the terrestrial vegetation of the palæozoic epoch. More than 700 plants have been enumerated by some botanists as belonging to the carboniferous strata; and M. Adolphe Brongniart, after considerably reducing the number of species, in consequence of many having been founded on the leaves, stems and fruit of one and the same plant, still reckons at least 500 species, one half of which are ferns. The greater part of the remainder belong to the dicotyledonous gymnosperms, of which some are true Coniferæ; and a much larger proportion belong to an anomalous family, departing very widely from any living type, to which the Sigillaria, Noeggerathia, and Asterophyllite are referred. They united some of the characters now peculiar to the Cryptogamia and dicotyledons respectively. It is very remarkable that none of the exogens of Lindley or dicotyledonous angiosperms of Brongniart, which comprise four-fifths of the living flora of the globe, have yet been discovered in the coal-measures, and a very small number, fifteen species only, of monocotyledons. If several of these last are true palms, an opinion to which Messrs. Lindley, Unger, Corda, and other botanists of note strongly incline, the question, whether any of the most highly organized plants occur in the primary or palæozoic strata, must at once be answered in the affirmative. If you wish to know how far the determination of these palms may be doubtful, I refer you to Adolphe Brongniart's discussion on the affinities of Musæites, Palmacites, Musocarpum, Trigonocarpum, and others in his recently published Essay on the genera of Fossil Plants*.

When we learn from botanists that there are now 11,000 species of living European plants, we must of course regard the 500 species of the coal at present known as a mere fragment of an ancient flora. Were we to explore the deltas of the Po and the Rhone as diligently as we have examined the coal-measures, should we obtain the remains of 500 determinable species, even now before the obliterating hand of time has effaced many of the markings by the destroying effect of heat, pressure, the percolation of water, and other causes? M. Adolphe Brongniart does not seem to suspect that the eocene flora was inferior in variety and richness to that which now decorates the earth, and yet he only describes 209 species of eocene plants.

If we wish to be convinced of the probable extent of our ignorance of the real state of the vegetation of the earth when the coal was formed, it may be well to reflect how seldom the fructification of coniferous trees has been met with in the coal-measures. Mr. Bunbury informs me that he never heard of more than one example,—that mentioned in the work of Lindley and Hutton, under the title of *Pinus anthracina*. I never saw any one fossil fir-cone of this age, either in the rocks or the museums of North America or Europe. Yet every

* Tableau des Végét. Foss., Dict. Univ. d'Histoire Naturelle. Paris, 1849.

collector is familiar with specimens of coniferous wood of the carboniferous period, displaying characters most nearly allied to the living Araucariæ. Göppert indeed convinced himself that many of the seams of coal examined by him in Germany, which have a structure like that of charcoal, are derived entirely from coniferous timber, and Brongniart gives five genera and sixteen species of Coniferæ of this epoch. The Araucarian pines have large cones, and we may expect to meet with the fruit of such trees hereafter, for Dr. Mantell tells me, he has found between forty and fifty fossil fir-cones in the Wealden of England, although not one is mentioned by Dunker, in his excellent work on the Hanoverian Wealden. The coal-seams of this freshwater deposit in Hanover, as I had an opportunity of attesting last summer, are almost exclusively made up of the needle-shaped foliage of pines.

To prevent ourselves therefore from hazarding false generalizations, we must ever bear in mind the extreme scantiness of our present information respecting the flora of that peculiar class of stations to which in the palæozoic era the coal-measures probably belonged. I have stated elsewhere my conviction that the plants which produced coal were not drifted from a distance, but nearly all of them grew on the spots where they became fossil. They constituted the vegetation of low regions, chiefly the deltas of large rivers, slightly elevated above the level of the sea, and liable to be submerged beneath the waters of an estuary or sea by the subsidence of the ground to the amount of a few feet. That the areas where the carboniferous deposits accumulated were low, is proved not only by the occasional association of marine remains, but by the enormous thickness of strata of shale and sandstone to which the seams of coal are subordinate. The coal-measures are often thousands of feet and sometimes two or three miles in vertical thickness, and they imply, that for an indefinite number of ages a great body of water flowed continuously in one direction, carrying down towards a given area the detritus of a large hydrographical basin, draining some large islands or continents on the margins of which the forests of the coal period grew. If this view be correct, we can know little or nothing of the upland flora of the same æra, still less of the contemporaneous plants of the mountainous or Alpine regions. If so, this fact may go far to account for the apparent monotony of the vegetation, although its uniform character may doubtless be in part owing to a greater uniformity of climate then prevailing throughout the globe. Mr. Bunbury has, I think, successfully pointed out in your Journal, that the peculiarity of the carboniferous climate consisted more in the humidity of the atmosphere and the absence of cold, or rather the equable temperature preserved in the different seasons of the year, than in its tropical heat * ; but we must still presume that colder climates existed at higher elevations above the sea.

That there was really a scarcity of flowering plants, other than the dicotyledonous gymnosperms, in those peculiar stations where that carboniferous flora grew with which we are acquainted, is, I think, most probable, for the predominance of Conifers and Ferns, Lepidodendra and Sigillariæ, would tend, by the mere occupancy of space, to cause other tribes to be feebly represented. This argument is not based on negative evidence, for botanists conceive that they have already obtained 250 species of ferns of the carboniferous æra, whereas the whole of Europe does not produce at present more than fifty species of the same family.

The flora of the primary period, or of the carboniferous and Permian strata, is called by Brongniart the age of Acrogens, from the great number of Ferns and Lycopodiums which then flourished ; and he styles the secondary period the age of Gymnosperms, because the Conifers and Cycads then prevailed in great numbers. But before we pass to the vegetation of the secondary rocks, we are met with a geological point of controversy of the utmost moment, on which we ought, if possible, to make up our minds, as it affects nearly all our generalizations when we contrast the fossil plants of the primary and those of the secondary rocks. Are the species of the Alpine anthracite palæozoic or secondary, carboniferous or liassic ? If the plants of Petit-Cœur near Moutiers in the Tarantaise, all identical with species of the carboniferous æra, and unmixed with any of an oolitic character, be correctly referred to the lias, such an exception to the rule of the restriction of particular assemblages of organic forms to particular eras, shakes every theory which rests on purely palæontological data to its very foundation. In the year 1828 M. Adolphe Brongniart published an account of twenty-five species of fossil plants from Petit-Cœur, twenty of which he was able to identify with car-

* Quart. Journ. Geol. Soc. 1846, vol. ii. p. 87.

boniferous species, M. Elie de Beaumont having found this assemblage of fossils in shales so intercalated with Jurassic schists containing Belemnites (the strata containing the plants and the Belemnites being parallel and conformable), as to lead him to infer that they were all parts of one formation. The dark shales containing Belemnites were recognized as a portion of certain adjacent rocks, in which Ammonites and other fossils characteristic of the Jurassic series abound. Other able geologists afterwards visited the spot, and at the Meeting of the French Geologists at Chambéry in 1841, they confirmed the views previously announced by M. de Beaumont. M. Favre, however, endeavoured to explain the anomaly by supposing that true carboniferous schists, originally underlying liassic strata, had been thrown together with them into a sharp anticlinal flexure, portions of which had been subsequently denuded; and he pointed out that in another part of the Alps similar schists, containing coal plants, constitute the conformable base of the liassic group*. Sir Roderick Murchison visited Petit-Cœur in the course of his Alpine excursions in 1847 and 1848, and gave a section showing that the plant-bearing anthracitic schists can be traced within one foot of the parallel dark shales containing Belemnites; and, to cite his own words, "the Belemnite and plant beds form parts of the same geological mass, the upper and lower parts of which are of similar composition, consisting of talcose schist and sandstone. In fact I cannot imagine how any geologist can look at this section, and not declare that the whole of these strata form a natural group of very small dimensions†." He also affirms, "that if, by a modification of the flexure theoretically suggested by M. Favre, we could get over the difficulty, the section at Petit-Cœur would be more deceptive than any he has ever examined, and until more proofs are obtained to the contrary, he must repeat his belief that the relations of the strata sustain the conclusions of M. E. de Beaumont‡."

When we are to choose between two alternatives, a most extraordinary displacement or contortion of stratified masses, or an exception to the laws elsewhere found to prevail in the geological distribution of organic remains, we must duly weigh, not only the singularity of the required mechanical disturbance, but also the extent of the palæ-

* Bulletin Soc. Géol. de France, vol. v. p. 263.

† Quart. Journ. Geol. Soc. vol. v. p. 177.

‡ Ibid. vol. v. p. 179.

ontological anomaly. When Sir R. Murchison and M. Escher, in a late survey of the Alps, observed a mass of limestone full of Jurassic fossils, a quarter of a mile long, resting unconformably on strata of the eocene or nummulitic group, in the Canton of Berne and the Grisons, they preferred to imagine any amount of folding of strata and of lateral displacement, rather than believe that an oolitic fauna with its Ammonites and other fossils had re-appeared on the earth after the older tertiary formations were deposited*. In like manner, when I visited the Danish island of Möen in 1836, and found the northern or glacial drift extensively interstratified with white chalk, of which a faithful and more detailed description has just been published by M. Puggaard, I stated in your Transactions that we were justified in assuming any amount of engulfment, contortion, or "entanglement" of the beds of the two formations, rather than believe the drift to have been contemporaneous with the white chalk and its flints†. In such cases it depends entirely upon the degree of our faith in the constancy of palæontological results, whether we attach a greater or less importance to superposition; and, consistently with this principle, geologists who have regarded the coal-plants and Belemnites of the Tarantaise as belonging to the same group, have laboured to show that the anachronism would not be so great, because the longevity of species in fossil plants, say they, exceeds that which obtains in the mollusca. Thus, the *Calamites arenaceus* is said to afford an example of a plant common to the coal-measures and the trias; but this, I believe, is incorrect, for this species, Mr. Morris tells me, was admitted into Mr. Prestwich's list of fossils from the coal-measures of Coalbrook Dale by mistake; and even were it true that the range of this and several other species was occasionally so great as to extend from the coal to the trias, or from the trias to the oolite, such cases would afford no parallel to the pretended occurrence in the Alps of a large assemblage of plants proper to the coal in the midst of a Jurassic fauna.

Some years after the publication in 1828 of M. Brongniart's first list of plants from the Alpine anthracite, that botanist had an opportunity of studying a still larger number of species from the same formation, so as to raise the number to forty, yet they all of them were

* Quart. Journ. Geol. Soc. vol. v. p. 246.

† Trans. Geol. Soc. Ser. 2. vol. ii. p. 257; see Puggaard, Möens Geologie, pp. 118–134 (1851).

still found to belong to the old carboniferous type, without the slightest intermixture of any newer or Jurassic forms. Still later, when M. Sismonda had satisfied himself, after visiting Petit-Cœur in company with M. Elie de Beaumont, that the evidence in favour of the Jurassic age of the fossil plants could not be impugned, he proposed to me to invite some English botanist to examine the fossils of the Alpine anthracite collected by him and deposited in the Museum at Turin, that they might again undergo a rigorous scrutiny. Our Foreign Secretary, Mr. Bunbury, undertook this task in 1848, and his paper, published in the fifth volume of your Journal, shows how entirely he confirmed the conclusions of M. Brongniart. At the same time, he reviewed the several conjectures which had been thrown out by naturalists to explain away or solve the enigma, and pronounced them to be all equally unsatisfactory. It had been urged by some writers, for example, that as the same coal plants have a wide range in space, both in latitude and longitude, reaching north and south from Melville Island to Alabama, and east and west from Indiana to Russia, they may have also had a great vertical range or duration in time. To this hypothesis there is this obvious answer:—Even in the Permian strata we perceive most of the carboniferous species beginning to disappear, whilst a perfectly new flora appears in the Triassic æra. Again, in the Liassic epoch, we find other distinct vegetable forms, not only in Europe, but in America and India, as will be seen by consulting for the United States the memoirs published by Prof. W. B. Rogers and myself on the oolitic coal-field of Virginia, and for the East by the accounts given by Captain Grant of the flora of the Cutch oolite*. If, on the other hand, we reflect on the wide extent, in the present state of the globe, of botanical provinces, each inhabited by its own assemblage of plants, we must regard the Vosges as not far distant from the Tarantaise Alps. Yet in the chain of the Vosges in Alsace we find, even at the period of the Lower Trias or Bunter, a vegetation wholly different from the carboniferous; and the Keuper again, or Upper Trias, displays according to Adolphe Brongniart another flora more approaching to the oolitic. What is still more decisive, in the Department of the Isère, at no great distance from the limits of the anthracite formation of the Alps, Jurassic strata occur

* Quart. Journ. Geol. Soc. vol. v. p. 136.

containing impressions of plants, which exhibit the usual characteristics of the oolitic flora, and include no Triassic, Permian or Carboniferous species.

Mr. Bunbury admits that certain living ferns have a very wide range in latitude, but still they offer no parallel in their geographical distribution in space to the supposed range in time of the anthracitic flora of the Alps; for, in proportion as each living species spreads farther and farther from its point of departure or chief centre of development, it becomes more and more mixed with the plants of other provinces. Nowhere could the botanist point to a group of forty trees, shrubs, or ferns flourishing at two remote points in the globe unmixed with foreign plants, and separated by two or more provinces of distinct species.

That we may not underrate the real amount of the supposed anomaly or exception to all ordinary rules, in the case of the anthracitic flora of the Alps (assuming it to be of Jurassic date), we must bear in mind that the beds containing it are not simply regarded by M. E. de Beaumont as the equivalents of the lias, but also as corresponding in age to the Oxford clay or middle oolite, as, for example, at Chardonnet near Briançon, to which Mr. Bunbury has alluded in his paper*. Hence we should be called upon to believe that certain species of Sigillaria and Stigmaria, of Asterophyllite, Lepidodendron, and Calamite, together with a multitude of Ferns, had lived on through the Carboniferous and Permian periods, through the lower and upper Triassic, and still survived in the eras of the lias, inferior oolite, and Oxford clay, without permitting any of the characteristic species of these several epochs to intrude themselves into their company.

The late celebrated palæontologist, M. Voltz, when he conversed with me on this subject in 1833 at Strasburg, had satisfied himself that certain islands in the tropics quite isolated from other lands, had continued to grow the plants in question throughout the vast interval of time which separated the coal from the lias, and that fragments of their stems and leaves were drifted by a marine current over the ocean and buried with belemnites and marine shells in muddy liassic sediment thrown down in the latitude of the Alps. However violent such an hypothesis may appear, no other has since been

* Quart. Journ. Geol. Soc. vol. v. pp. 133, 136.

invented of a more plausible kind, unless we escape from the difficulty by explaining away what is called "physical evidence" or the "order and position of the beds." It is conceded on all hands that in no region of the globe, hitherto studied by geologists, has the original arrangement of strata been subsequently so much altered by complicated foldings and dislocations, and by metamorphic action, which last has sometimes superinduced a crystalline structure on older formations, while those of newer date retain their ordinary mineral condition.

In a district of such chaotic confusion, we may well despair of being able to trace out the true chronological sequence of fossiliferous groups, and we therefore hail with pleasure the discovery of an undisturbed region not very remote, where strata wearing the same mineral and palæontological aspect occur. It appears that recently, in 1850, the two Italian professors, Meneghini and Savi, have detected near Volterra anthracitic schists containing coal plants like those of the Alps, such as *Pecopteris arborescens* and *Annularia longifolia*, on which beds of lias with the ordinary marine shells repose. These schists belong to the *Verrucano* or oldest conglomerate of Italy, which, so long as no fossils were obtained from it, had been regarded in Tuscany as the base of the lias, but which will henceforth be classed as a carboniferous conglomerate and schist supporting the Jurassic series. Such facts seem to have a direct bearing on the enigmatical question of Petit-Cœur, from the circumstance that in many parts of the Alps, as in the well-known instance of the Valorsine, which I have myself examined, the plant-bearing schists are associated with a conglomerate doubtless analogous to the Verrucano. This fact Sir Roderic Murchison and Professor Heer have remarked, when commenting on the statements of Signori Meneghini and Savi*. We have merely then to imagine, that in the Tarantaise Alps, as in Tuscany, Jurassic strata were first thrown down on horizontal coal-measures, and that in the Tarantaise these were afterwards crumpled and folded together by more than one series of movements, which extended in the central Alps, as we know, even to the cretaceous and eocene deposits. When we consider that occasionally the Permian group is wanting in England, and the Muschelkalk universally, we ought not to be surprised

* Quart. Journ. Geol. Soc. vol. vi. p. 382 ; and Heer, Mittheilungen der Naturf. Gesellsch. in Zurich, January 1850.

at the omission in another part of Europe of all the beds between the coal-measures and the lias; and it seems clear that if we assent to the doctrine that the Verrucano of Volterra is a palæozoic rock, we are simply required to transfer to Tuscany the flexures and inverted position so characteristic of the beds in many parts of the Alps, and we should have the enigma of Petit-Cœur repeated.

Having offered these observations on the fossil plants of the primary strata, a few words may suffice for the flora of the secondary and tertiary eras, for in these all botanists seem to agree that some highly developed families of monocotyledons, such as the Liliaceæ and Palms, occur. In the inferior oolite of England, we find the fruit of Podocarya, so well described and illustrated by Dr. Buckland in his Bridgewater Treatise, and which seems clearly to have been an endogen closely allied to the Pandanus or Screw Pine.

In the strata from the triassic to the Purbeck inclusive, comprising Brongniart's age of gymnosperms, plants of the family of Zamia and Cycas, together with Coniferæ, predominated in Europe far more than anywhere now on the globe in corresponding latitudes. They must have given to the flora of this period a peculiar aspect, but our data are too scanty to entitle us to affirm that the vegetation of this second epoch was on the whole of a simpler organization than that of our own times. In Bronn's catalogue 223 species only of plants are enumerated in all the rocks ranging from the lias to the middle oolite inclusive. Not a few even of these are referred to Algæ, 29 species of that tribe having been obtained from the lithographic slate of Solenhofen and the neighbourhood, all from one subdivision of the oolite.

The cretaceous strata are classed by Brongniart together with the tertiary in the last of his three periods before alluded to, namely the age of angiosperms. The two upper divisions of the Wealden, the Hastings sand and Weald clay, may probably, for reasons to which I shall allude in the sequel, be referred to the same age. In regard to the rocks ranging from the lower greensand to the Maestricht beds inclusive, they are chiefly marine, and we have therefore as yet but little information respecting the contemporary plants which grew on the land, but such as are known display a transition-character between the vegetation of the secondary and that of the tertiary formations. Coniferæ and Cycadeæ still continued to flourish, and even a tree-fern has been detected in the ferruginous sand of the lower cretaceous group in the Ardennes in France. Yet this vegetation is referred by Brongniart to the age of angiosperms, some well-marked leaves of dicotyledonous trees having been found in Germany, in the cretaceous quader-sandstein and pläner-kalk. The co-existence of these with numerous cycads and with the great reptiles, the Iguanodon, Ichthyosaurus, Plesiosaurus, and Pterodactyl, is not unimportant, as it proves that there was nothing in the atmosphere so favourable to the predominance of gymnosperms and to a rich reptilian fauna, which was fatal to the existence both of monocotyledonous and dicotyledonous angiosperms.

You are aware that in many localities in the neighbourhood of Paris there is a formation called the pisolitic limestone, intermediate in position between the white chalk and the oldest eocene tertiary, and that there has been much controversy whether it should be referred to the cretaceous or to the eocene period. That it belongs to the age of the Maestricht chalk seems to be the preferable opinion, and some have considered the limestone of Sezanne near Paris to be of the same age; while others regard the latter as lower eocene. In this limestone we have a species of Hepatica, the *Marchantia Sezannensis*, Brongniart, preserved in a kind of travertin, with a species of moss. How rarely must we expect such discoveries to be made in rocks of such ancient date! If occasionally we obtain a glimpse of the existence of a lichen, a Jungermannia, or a moss, in travertin or amber, it is all the evidence we can look for of whole families of plants which may have played as great a part in every successive geological epoch, as now in the living creation.

The number of plants hitherto obtained from tertiary strata of different ages is very limited, but is rapidly increasing. They have been met with chiefly in isolated spots; and all those examined by M. Ad. Brongniart, even the pliocene fossils, are considered by him to be distinct from living species. They are referable to a much greater variety of families and classes than the same number of species taken from secondary or primary formations, the angiosperms bearing the same proportion to the gymnosperms and acrogens as in the present vegetation of the globe. This greater variety may doubtless be partly ascribed to the greater variety of stations in which the plants grew, as we have in this instance an opportunity, rarely enjoyed in studying the secondary fossils, of investigating inland or lacustrine deposits, accumulated originally at different heights above the sea, and inclosing the memorials of the floras washed down from the adjoining mountains.

The mutual dependence of plants and animals on each other is such, that we may fairly presume that the relative numbers in each of these kingdoms of Nature did not depart very widely in any former geological period, especially the tertiary, from the proportion now prevailing. It is true that the fossil flora of the palæontologist is meagre in the extreme when contrasted with the fossil fauna, but this arises from the fact that almost all our fossil species of animals are aquatic, whereas there are comparatively few aquatic plants now existing in the world, and they seem not to have been more abundant at remote epochs. If we compare the terrestrial fossil fauna with the terrestrial flora, the disproportion no longer holds good.

Professor Bronn has enumerated in his 'Index Palæontologicus,' 24,000 fossil animals and only 2050 fossil plants, the proportion being only one plant for twelve animals, whereas in the living creation he estimates the relative proportions to be seven species of plants for ten of animals. But although the value of the botanical data on which we reason, may only be as one to twelve when compared to our zoological information, we seem already to have sufficient evidence, that there have been at least four, if not five, revolutions since the cretaceous era in the species of plants inhabiting the earth; and during these successive changes there is no manifest elevation in the grade of organization, implying a progressive improvement in the floras which succeeded each other from the eocene to our own epoch. The plants of the lower eocene found at Sheppey include genera of which the organization is as perfect as in those found much higher in the eocene series, (in the gypsum, for example, of Paris); and the same may be said of the miocene and pliocene assemblages of plants.

Let us now turn to the fossils of the animal kingdom, and inquire whether, when they are arranged by the geologist in a chronological series, they imply that beings of a more highly developed structure and greater intelligence entered upon the earth at successive periods, those of the simplest organization being the first created, those more highly organized being the last. It may be affirmed that the knowledge acquired of late years of the Silurian fauna reduces at once the theory of successive development within very narrow limits; for we discover even in the lower Silurian, a full representation of the Radiata, Mollusca, and Articulata proper to the sea; and regarding it as a marine fauna confined to those three classes, it might almost seem to imply a more perfect development than that which peoples the ocean of our own times. Thus in the great division of Radiata, we find asteroid and helianthoid zoophytes, besides crinoid and cystidean echinoderms. In the Mollusca, M. Barrande enumerates, in Bohemia alone, the astonishing number of 250 species of cephalopoda. In the Articulata we have the crustaceans represented by more than 200 species of trilobites, not to mention other genera.

The remains of fish, hitherto referred to lower Silurian rocks, have proved on closer investigation to be spurious, those of the Wenlock and Caradoc groups in England having been found to be portions of zoophytes or crustaceans, or cystidean plates, and the ichthyolites, supposed to be of like antiquity in the United States, being now ascribed by some geologists to the upper Silurian, by others to the Devonian era. Nevertheless, in the Bala limestone in Wales, an undoubted member of the lower Silurian, our Government Surveyors have met with coprolites, which when analysed yielded between 30 and 40 per cent. of phosphate of lime, and bear witness to the existence of Vertebrata in the most ancient seas. Professor John Phillips, in his memoir on the Malvern Hills and the palæozoic districts of Abberley and Woolhope, observes, that, on comparing the fossils of the lower with the upper Silurian groups, he could discover no signs whatever that the lapse of time had produced any improvement or development in organic forms*.

In the upper Silurian, we find, in addition to all the genera of the invertebrate classes before enumerated, placoid fish, some of which Agassiz refers to the cestraciont sharks, a family still existing in the Australian seas, and which Prof. Owen places at the top of the highest of eleven orders of fishes, ranged in an ascending scale of organization.

The marine character of the Silurian rocks of Europe and North America is sustained even in India by strata of the same age, as appears from the late investigations of Captain Strachey, who has ob-

* Mem. of Geol. Survey of Great Britain, 1848, vol. ii. p. 75.

tained from them a fine series of fossils from the northern slope of the Himalaya mountains, more than 200 miles north-west of Cashmere. Having therefore as yet only discovered the deep-sea formations of this remote period, we know nothing of the contemporaneous terrestrial fauna. It is but lately indeed that our surveyors in Shropshire have determined that land did exist at that period, and have begun to trace out the boundaries of the shores of a Silurian sea.

In these most ancient of fossiliferous strata, I can neither discern any signs of the dawn of organic life, or of an immature and incipient condition of the animate creation, and as little proof of a restless and chaotic state of the planet, as if earthquakes were more frequent and violent, or the waves loftier, or the marine currents swifter than at present. The corals and crinoids imply pure, clear, and many of them tranquil water, the pebbles are not larger than those of succeeding epochs, and the ripple-marked sands at the bottom of the series, as seen for example in the Potsdam sandstone of Vermont, precisely resemble those of a modern beach. The doctrine of intermittent paroxysms, with long intervening periods of repose, is certainly preferable to a theory of chronic turbulence, for those who despair of explaining all ancient disturbances of the earth's crust by the cumulative effect of prolonged movements, or the indefinite repetition of shocks of minor violence. But I must refer you for my views on this subject to my Anniversary Address of last year.

Some eminent naturalists have assumed that the earliest fauna was exclusively marine, because we have not yet found a single Silurian helix, insect, bird, or terrestrial reptile or mammifer. But if any one wishes to convince himself of the rashness and unsoundness of such generalizations, he need only study the results of a recent dredging expedition, conducted by Prof. E. Forbes, not in seas of considerable depth and somewhat remote from land, like those in which the greater part of the Silurian strata were deposited, but near our coast. I allude to the observations laid before the British Association, at Edinburgh, in 1850, by Messrs. Forbes and MacAndrew, who in the summer of that year explored the bed of the British seas from the Isle of Portland to the Land's End, and thence again to Shetland. They have recorded and tabulated the numbers of the various organic bodies, obtained by them in 140 distinct dredgings, made at different distances from the shore, varying from a quarter of a mile to forty miles. The list of marine invertebrate animals, both radiata, mollusca, and articulata, is by no means inconsiderable, but very few traces of any vertebrate animal were found. When these occurred, (in five or six cases only), they were limited to fish, consisting of a few ear-bones, as in the Crag, and of small vertebræ. No cetaceans were met with, no relics of terrestrial mammals, although at some points they approached near to the shore so as to dredge up a few fragments of wood. In two or three instances only were any articles of human manufacture, such as a glass bottle, fished up. If reliance could be placed on negative evidence, we might deduce from such facts, that no cetacea existed in the sea, and no reptiles, birds, or quadrupeds on the neighbouring land.

One solitary helix, which had been carried out to sea by a hermit crab, was brought up from a depth of six fathoms; but no freshwater mollusca were obtained, probably because their shells are in general very fragile.

The absence even in the coal-measures of land-shells is a singular and, if I mistake not, significant fact. The known living species of the genera Helix, Cyclostoma, Bulimus, Achatina, Pupa, and Clausilia exceed 2000 in number; and not one of these genera, nor any of the pulmoniferous mollusca, such as Lymneus, Planorbis, Physa, &c., have as yet been detected in any one of the primary strata from the Silurian to the Permian inclusive. Yet no one who reflects on the great number of palæozoic marine shells, and the extent to which they can be arranged under the genera or families established for the classification of recent testacea, can reasonably doubt that the lands of those periods were also inhabited by mollusca.

Some few shells of the coal-measures have been referred to the genus Unio, and others to an annelid allied to Spirorbis, and called Microconchus, probably an inhabitant of brackish water. That other land and freshwater shells should be so rare as hitherto to have escaped detection surprises me the less when I remember how diligently I searched in vain in the alluvial strata laid open in the delta of the Mississippi at low-water for similar remains. In some of the ancient fluviatile mud of the valley of the Mississippi, which I have compared to the loess of the Rhine, land and freshwater shells of existing species abound, but they must be extremely scarce, in the low region of cypress-swamps, near the sea, where we behold conditions more nearly resembling those which must have prevailed when the ancient coal-measures were formed.

Already some light has been thrown on the Articulata of the carboniferous period, some Arachnidæ having been procured from strata of this age. Two species of Coleoptera of the Linnæan genus Curculio, a neuropterous insect resembling a Corydalis, and another of the same order related to the Phasmidæ, have been met with in the iron-stone of one coal-field, that of Coalbrook Dale. As an example of the insectivorous arachnidans, I may mention the Scorpion of the Bohemian coal, figured by Count Sternberg, in which even the eyes, skin, and minute hairs were preserved*. We need not despair therefore of obtaining eventually fossil representatives of all the principal *orders* of hexapods and arachnidans, although the species found in the coal may never constitute a thousandth part of those which inhabited the earth at the era in question.

The inference of Professor Heer, that insects were very rare at that period, owing to the scarcity of flowers in those forests in which Ferns, Lycopodia, and Equiseta predominated, does not appear to me legitimate; nor can I agree with him in thinking it probable that lepidopterous insects were first created in the tertiary period, merely because the only well-determined specimens of that order yet known to palæontologists have come from tertiary strata.† I have myself found the elytra of beetles both in peat and shell-marl in Scotland, as well as in the pleistocene freshwater beds of the Norfolk cliffs at Mundesley, but I have never seen a single moth or butterfly in any recent deposits; and if we were to search these for ages, could we expect to gain from them a much clearer knowledge of the 11,000 insects now living in Great Britain, than that which the coal-measures have afforded of the carboniferous insects?

When Agassiz described 152 species of ichthyolites from the coal, he found them to consist of 94 placoids belonging to the families of Shark and Ray, and 58 ganoids. One family of the latter he called "sauroid fish," including the Megalichthys, Holoptychius, and others often of great size, and all predaceous. Although true fish, and not intermediate between fish and reptiles, they seem undoubtedly to have been more highly organized than any living fish, reminding us of the skeletons of true saurians by the close sutures of their cranial

* Buckland, Bridgewater Treat. p. 409.

† Heer, Quart. Journ. Geol. Soc. vol. vi. Part 2. p. 68.

bones, their large conical teeth, striated longitudinally, and the articulations of the spinous processes with the vertebræ. Until very lately it was imagined by some geologists that this ichthyic type was the more highly developed, because it took the lead at the head of Nature before the class of reptiles had been created. For it was taken for granted that reptiles were first introduced into the earth in the Permian period, many palæontologists considering that the limits of our knowledge of the existence of any class of animals in past time, coincided exactly with the date of its creation.

At length in the year 1844, M. Herman von Meyer described, under the name of *Apateon pedestris*, the first skeleton of a reptile from the coal-measures. He supposes this animal, found at Münster-Appel, in Rhenish Bavaria, to be nearly related to the Salamanders. Three years later, in 1847, Professor von Dechen discovered in large concretionary nodules of clay-ironstone, in the coal-field of Saarbrück, the skeletons of no less than three distinct species of air-breathing reptiles, which were figured and described by the late Professor Goldfuss, under the generic name of Archegosaurus. These valuable additions to the carboniferous fauna were procured at the village of Lebach, between Strasburg and Treves. The species of ichthyolites and coal-plants in the accompanying shales leave no doubt of the exact age of the formation. The largest of the three species, called *Archegosaurus Decheni*, must have been three feet six inches long. Fortunately, the skull, teeth, and the greater portion of the skeleton, nay, even a large part of the imbricated covering or horny scales of the skin, have been faithfully preserved in two of the specimens. They were considered by Goldfuss to be saurians, but Herman von Meyer regards them as most nearly allied to the Labyrinthodon, and therefore connected with the batrachians as well as the lizards. The remains of the extremities leave no doubt that they were quadrupeds, "provided," says Von Meyer, "with hands and feet terminating in distinct toes; but these limbs were weak, serving only for swimming or creeping." The same anatomist has pointed out certain points of analogy between their bones and those of the *Proteus anguinus*; and Prof. Owen has observed to me that they make an approach to the *Proteus* in the shortness of their ribs*.

Even before any intelligence of these European discoveries had

* Goldfuss, Neue Jenaische Lit. Zeit. 1848; and Von Meyer, Quart. Journ. Geol. Soc. vol. iv. Part 2. p. 51.

reached me, I had satisfied myself of the genuineness of the reptilian foot-prints, first observed in 1844 by Dr. King at Greensburg in Pennsylvania, and which I examined carefully in his company in 1846*. They occur as casts on the lower side of slabs of sandstone, in the midst of the coal-measures, and were evidently made by a large air-breathing animal, walking over soft mud which afterwards dried and cracked in consequence of shrinking. This American fossil appears to have been a much broader animal than the European triassic Cheirotherium and of a different genus. Its stratigraphical position is unequivocal, as it is imbedded in coal-measures containing impressions of Lepidodendron, Sigillaria, and Stigmaria, some of the plants being specifically identical with those of the European coal. I alluded in my last Anniversary Address to other foot-prints of a large reptile, supposed to be of considerably older date, found in 1849 by Mr. Isaac Lea, in red sandstone referred to the Devonian period, at Pottsville, near Philadelphia. These appear to be referable to a different species, and have been lately shown by Prof. H. D. Rogers to belong to the lowest part of the carboniferous series, and are therefore not much more ancient than the foot-prints of Greensburg, above mentioned.

In the course then of the last six years, memorials of reptile life have been traced back from the Permian to the bottom of the Carboniferous deposits, or nearly as far as any land-plants, and farther than the oldest land-shells, yet known. They have been carried down as it were, in six years, through a voluminous series of documents 15,000 feet or more in thickness; and we ought therefore by no means to despair of tracing birds or any other inhabitants of the land to periods as remote.

I will now proceed to consider the bearing of the organic remains of the secondary formations, from the trias to the chalk inclusive, on the doctrine of successive development. Respecting the Invertebrata of this vast period, I need only say, that memorials of all the aquatic tribes are as abundant as we could expect to find those of living invertebrata in the bed of the actual seas. But it is worthy of notice, that the freshwater and terrestrial mollusca are usually, as in older formations, very rare or entirely wanting. No helices or other land shells have been collected, for example, from the lias, although Mr.

* See the Author's Second Visit to the United States, vol. ii. p. 305.

Brodie in his valuable 'History of British Insects' informs us, that in the marl-stones and shales of this age, in Gloucestershire and other parts of the West of England, there are numerous remains both of insects and plants occasionally mingled with marine shells, sometimes also with freshwater mollusca of the genera Cyclas and Unio. One shale containing Cypris is charged with the wing-cases of Coleoptera, and some nearly entire beetles of which the eyes are preserved. The nervures of the wings of the neuropterous insects are also found in a very perfect state in the same bed. Throughout an extensive district several bands of this lias have been termed insect-limestone, in consequence of the great number of such fossils, no less than 300 specimens of hexapods having been obtained, comprising both wood-eating and herb-devouring beetles of the Linnæan genera Carabus, Elater, and others, besides Grasshoppers (*Gryllus*) and detached wings of Dragon-flies and May-flies, or insects referable to the Linnæan genera Libellula, Ephemera, Hemerobius, and Panorpa, the whole assemblage belonging to no less than twenty-four families. These have evidently been washed down into the sea by a river, which also brought down the leaves of ferns and monocotyledons, together with fragments of other plants, possibly dicotyledonous*. That no shells of snails or any air-breathing testacea have been yet obtained must be a mere accident, and we may consider ourselves in this and many other districts as treading on the threshold of discoveries, which may soon make us better acquainted with the contemporaneous flora and fauna of the dry land.

Until the year 1846, when Dr. Dunker described the Wealden beds of the North of Germany, no well-determined specimen of the genus Planorbis had been detected in beds older than the eocene; and the first species of Lymneus, more ancient than those of tertiary date, was found by the same geologist. In the four years which have since elapsed, Prof. E. Forbes has not only met with various species of these genera in each of the three divisions of the Purbeck in Dorsetshire, but has also obtained from the same rocks Valvata, Physa, and Melania in abundance, together with the fruit of Chara, previously supposed to be characteristic of strata newer than the uppermost chalk. You will find that some able palæontologists have been disposed to lean on the absence of pulmoniferous mollusca in all strata antecedent to the eocene, in support of the theory of successive

* Prof. Buckman, Quart. Journ. Geol. Soc. vol. vi. p. 417.

development, arguing that these tribes, possessing as they do a high grade of organization (although by no means the highest among the mollusca), came latest in the order of creation, or were not formed until the tertiary epoch. It is therefore important that we should have made so large an accession of fossils referable to this division, some of the species approaching very closely in their forms to living English shells, in strata of such antiquity; for the recent researches of Prof. Forbes leave little doubt that the Purbeck belongs to the oolitic type, judging from its intercalated marine shells and echinoderms, whereas the marine mollusca of the Hastings sands, collected by Mr. Austen, imply that that division of the Wealden has a closer affinity to a lower cretaceous fauna. According to this view, the genera Planorbis, Lymneus, Valvata, Physa, and others, are at once carried down from the eocene group to the oolite, and such a fact should for ever warn us against reasoning in future on mere negative evidence, as to the non-existence of all similar families of mollusca in the primary periods.

In speaking of the Vertebrata of the secondary rocks, I need only observe respecting the fish and reptiles, that they were most fully developed in their organization, the Iguanodon and some other contemporary saurians making even a nearer approach in many characters of their osteology to warm-blooded quadrupeds than any reptiles now living on the globe. The only points therefore in secondary palæontology to which it seems necessary to allude are, first, the foot-prints of birds in the trias of North America, secondly, the fossil mammalia of the Stonesfield oolite, and thirdly, the extreme scarcity, if not entire dearth, at present, of cetaceous remains in rocks older than the eocene.

First, as to the age of the red sandstone containing bird-tracks in the valley of the Connecticut river, I have little doubt that this rock is at least as old as the European trias. It contains several species of fossil fish of the ganoid genus Ischypterus of Egerton, by which it is distinguished from those coal-bearing strata of oolitic or liassic age, near Richmond in Virginia, which I have described in the third volume of your Quarterly Journal. The genus Ischypterus is of a peculiar type, and therefore of small value in settling a chronological question, but the want of a decidedly heterocercal tail may perhaps raise some presumption against their being Permian. That they are newer than the true or primary coal-measures may be deduced from still more satisfactory data. The old carboniferous formation enters into all the flexures of the Appalachian chain, whereas the red sandstone of the Connecticut, or at least its equivalent in New Jersey, reposes in many places unconformably on the denuded edges of the inclined or vertical Appalachian beds.

When I first examined these strata of shale and sandstone near Jersey city, in company with Mr. Redfield, I saw at once from the ripple-marked surface of the slabs, from the casts of cracks, the marks of rain-drops, and the imbedded fragments of drift-wood, that these beds had been formed precisely under circumstances most favourable for the reception of impressions of the feet of animals, walking between high and low water. In the prolongation of the same beds in the valley of the Connecticut, there have been found, according to Professor Hitchcock, the foot-prints of no less than thirty-two species of bipeds and twelve of quadrupeds. Thirty of these are referred to birds, four to lizards, two are believed to be those of chelonians, and six to be batrachians, the remaining two being doubtful. They have been observed in more than twenty localities, which are scattered over an area of nearly eighty miles from north to south in the states of Massachusetts and Connecticut. After visiting several of these places, I entertained no doubt that the sand and mud were deposited on an area which was slowly subsiding all the while, so that at some points a thickness of more than 1000 feet of superimposed strata had accumulated in very shallow water, the foot-prints being repeated at various intervals on the surface of the mud throughout the entire series of superimposed beds. When I first examined this region in 1842, Professor Hitchcock had already seen 2000 impressions, each of them indented on the upper sides of layers of shale, while the casts of the same, standing out in relief, always protruded from the lower surface of the incumbent strata. Had they been concretions, as some geologists at first contended, they would have been occasionally found projecting from the upper sides of strata of sandstone. I was also much struck when following each single line of foot-marks, to find how uniform they were in size and how nearly equidistant from each other, whereas on turning to a larger or smaller set of impressions, the distance separating any two tracts in the same series immediately increased or diminished, there being an obvious proportion between the length of the stride and the dimensions of the creature which walked over the mud. There are also a great number of examples where the trifid impressions exhibit three marks of phalangeal bones for the inner toe, four for the middle and five for the outer one, as in the feet of living tridactylous birds, and in each continuous line of steps the three-jointed and five-jointed toes are seen to turn alternately right and left. In one slab found at Turner's Falls on the Connecticut by Dr. Deane, the fine matrix has retained marks of the integument or skin of the foot. This specimen is now in the museum of Dr. Mantell, and the impression was recognized by Prof. Owen as resembling the skin of an ostrich and not that of a reptile. Such a test, in addition to the other evidence before mentioned, should, I think, remove all scepticism in regard to the ornithic nature of most of these bipeds. The size indeed of some of the fossil impressions seemed at first to raise an objection against their having belonged to birds, as it far exceeded that of any living ostrich, but the Dinornis and other feathered giants of New Zealand have removed this difficulty. The foot-prints are accompanied by numerous coprolites, and Mr. Dana has derived an ingenious argument from the analysis of these bodies, the proportion they contain of uric acid, phosphate of lime, carbonate of lime, and organic matter, showing that, like guano, they are the droppings of birds rather than of reptiles*. Still it is asked, whether, if birds were so abundant, we ought not to meet with some of their bones in a fossil state,—a remark, be it observed, which is equally applicable to the associated quadrupedal imprints. In reference to this question, I took pains, when on the shores of the Bay of Fundy, after I had examined the red sandstone of the Connecticut, to inquire whether, in digging trenches through the red mud of recent origin, from which the tide has been excluded by sea-banks, they had ever found the bones of birds, and I could hear of no instance, although I saw the sandpiper, or *Tringa minuta*, making every day those lines of impressions in the mud bordering the estuary which I have described and figured in my 'Travels.' My friend Dr. Webster, of Kentville, Nova Scotia, has recently sent me some fine examples of rain-drops, which he saw formed during a shower on this modern mud, and casts of which project in relief from the under-side of an incumbent layer of the same argillaceous deposit, thrown down during a subsequent rise of the tides. Thus marked and traversed by cracks caused by shrinkage, and containing the foot-prints of birds, they

* Amer. Journ. of Science, vol. xlviii. p. 46.

present a singularly perfect counterpart of many of the old triassic shales above described.

Mr. Darwin tells us in his 'Journal of a Voyage in the *Beagle*,' that the South American ostriches, although they live on vegetable matter, such as roots and grass, are repeatedly seen at Bahia Blanca, lat. 39° S., on the coast of Buenos Ayres, coming down at low water to the extensive mud-banks, which are then dry, for the sake of feeding on small fish. Over such mud-flats, birds of different sizes, together with alligators, turtles, and other reptiles, may wander and leave their foot-prints, and yet, although swarming by myriads, may leave none of their bones in the newly deposited sediment. I have searched in vain, year after year, in the shell-marl of Scotland, for the evidence of the existence of a single bird, in a deposit made up bodily of shells of the genera Lymneus, Planorbis, Succinea, and Valvata, and in which the skeletons of deer, oxen, and other quadrupeds are met with in considerable numbers, although we know that before the lakes were drained, which yield this marl so largely used in agriculture, the surface of the waters and the bordering swamps were covered with the wild duck and wild swan, and with teal, herons, curlews, snipes, and other fowl. They have left no fossil memorials behind them, because if they perished on the land, their bodies decomposed or became the prey of carnivorous animals; if on the water, they were buoyant and floated till they were devoured by predaceous fish or birds, and in warmer countries by reptiles, such as the alligator. But the same causes of obliteration have no power to efface the foot-prints which such creatures may have left on an ancient mud-bank or shore, and these, like the ripple-mark on the surface, or the casts of crevices formed by the shrinkage of mud during desiccation, may be as imperishable as any other portion of the solid rock.

We have at present no fossil remains of birds in the primary formations of any country, and none in the secondary, except the impressions, above alluded to, in the red sandstone of New England, and a few British specimens of bones from the oolite of Stonesfield and the Wealden of Tilgate Forest. After I had been informed by Mr. Bowerbank that among several bones of Pterodactyls from Stonesfield he had met with one from the same locality which by its microscopic structure was clearly referable to a bird, I proposed to Mr. Quekett of the College of Surgeons to examine the fossils of the same class in the Society's Museum, a task which he kindly undertook. He reports to me that all the bones, more than twenty in number, are those of birds, except two which belong to Pterodactyls and are characterized by that minute structure which Mr. Bowerbank found, in 1847, in the Pterodactyls of the chalk. The Wealden fossil which Cuvier and Mantell once referred to a wading bird seems to be referable to a Pterodactyl, for reasons pointed out by Prof. Owen. But Dr. Mantell is still of opinion, that he had in his collection from the Wealden a portion of the ulna of a bird on which there was a distinct row of slight eminences, like the tubercles on the ulna of some birds, for the attachment of the large wing-feathers. This specimen has been transferred to the British Museum, and well deserves to be sought for and figured.

The *Protornis Glariensis* of H. von Meyer, found in the slates of Glaris in Switzerland, was formerly cited as an example of a cretaceous bird. But according to the classification of the Alpine strata lately proposed by Sir Roderick Murchison, you will observe that this schist is about the age of the nummulitic limestone, and therefore an eocene rock*.

The long-winged bird of the chalk, called Cimoliornis by Prof. Owen, formerly considered as allied to the albatros, has now proved, as Mr. Bowerbank had inferred from the structure and proportions of the bone-cells, to be a Pterodactyl, the jaws, skulls, and wing-bones of three species of these flying reptiles having been found in the white chalk without flints, above the chalk marl in Kent. Mr. Bowerbank estimates the largest of these species, judging from the size of the bones as compared to corresponding portions of Pterodactyls, of which we have the more or less perfect skeletons, to have been so gigantic that it measured 16 feet 6 inches from tip to tip of the outstretched wings†.

Some geologists have suggested that these flying reptiles, when very abundant, may have performed many of the functions now discharged in the animal kingdom by winged and feathered bipeds. It may be so; but the numerous foot-prints of tridactyle bipeds of various sizes in the trias of North America, and the fragments of ornithic bones from Stonesfield, above adverted to, should put us on

* Quart. Journ. Geol. Soc. vol. v. p. 199.

† Zool. Proceedings, Jan. 14, 1851.

our guard against hastily assuming even the scarcity of this great class in what has been termed the Age of Reptiles.

If we consult Prof. Owen's work on British Fossil Mammalia and Birds, we find 229 figures devoted to the illustration of the mammalia, and only seven figures to the birds. Three species only had been obtained in 1846 from the English eocene beds, although nineteen British mammalia were known when that treatise appeared. Cuvier's investigations had long before made known to us, that in the eocene gypsum of Montmartre there were ornitholites of the families Accipitres, Gallinaceæ, Grallatores, and Palmipedes, and it is therefore remarkable that the freshwater deposits of the Isle of Wight and Hordwell Cliff, which had yielded freshwater shells in abundance for half a century, had afforded us no insight into the state of the contemporaneous feathered creation.

The next point in the palæontology of the vertebrata of the secondary formations, relates to the fossil mammalia of the slate of Stonesfield. The manner in which the lower jaws of extinct quadrupeds of no less than three species are imbedded in an oolitic matrix, prevents the possibility of any cavil as to the locality from whence they were all derived, and the rock itself is well ascertained to belong to the lowest division of the oolitic system of England. In their state of preservation they rival the beautiful fossils of the Paris gypsum, or those of corresponding eocene date recently obtained from Hordwell Cliff. After the animated discussions which have taken place in this room, it would be a waste of time to repeat to you the arguments by which the Hunterian Professor proved that jaw-bones, consisting of a single piece with double-fanged teeth and convex condyles exhibiting well-developed coronoid processes, cannot have belonged to fish or reptiles. I shall merely allude to the late discovery of a more perfect jaw, which enabled Professor Owen's anatomical skill to decide that the angular process of the *Amphitherium Prevostii* was bent inward in a slighter degree than in any of the known marsupialia. The fact of the inflection not exceeding that observable in the jaw of the living mole or the hedgehog, turns the scale in favour of the affinities of the *Amphitherium* to the placental insectivora, although it still approximates in some points of its osteology to the Myrmecobius and other marsupials of Australia.

But the precious relic of another mammiferous genus discovered in the slate of Stonesfield, called *Didelphys Bucklandi* by Broderip, and *Phascolotherium* by Owen, manifests so complete an agreement with the living genus *Didelphys* in the number of premolar and molar teeth, in the general form of the jaw, and in the extent and position of its inflected angle, that we can hardly doubt its marsupial character,—a conclusion of no small importance, because in this case we have osteological evidence that both the placental and marsupial classes of mammalia were already in being in an early part of the oolitic era, just as opossums now coexist with skunks on the American continent. Several insects, and among them the elytra of beetles, on which these small quadrupeds may have fed, are preserved in the same rock; and Prof. Owen remarks that some carnivorous quadrupeds of coeval date could scarcely have been wanting to keep down the numbers of the Phascolotheres and Amphitheres, which were probably, like the quadrupeds now most nearly allied to them, quick breeders*.

By a singular accident, no other bones have been collected of the skeletons of the seven individuals as yet found at Stonesfield, except seven half lower jaws; a fact, demonstrating in a marked manner the fragmentary nature of the memorials handed down to us of an ancient terrestrial fauna. Yet no small diligence has been used by collectors for more than a quarter of a century to obtain even the smallest isolated bones of fish and reptiles from these beds. I can only compare the capricious chance which has hitherto put us in the exclusive possession of these seven jaws, with the equally strange accident recorded by Dr. Mantell, in his career of discovery in the Wealden. He computed that in the course of twenty years he had found teeth and bones of the Iguanodon which must have belonged to no less than 71 distinct individuals, varying in age and magnitude from the reptile just burst from the egg, to one of which the femur measured 24 inches in circumference. Yet it was not until the relics of all these individuals were known that a solitary example of part of a jaw-bone was obtained. As in other branches of inquiry one invention or discovery usually elicits another of the same kind, so, when at length the first Iguanodon's jaw had been procured, a second was soon detected in a different locality, and then the fragment of a third brought to light from the stores of the British Museum. The solidity of these jaw-bones, and the strength with which several teeth fixed in

* Brit. Foss. Mamm., Introduction, p. 14.

them adhere to their sockets, render it more than ever inexplicable why hundreds of similar detached teeth should have been previously collected by naturalists without their having fallen in with a single fragment of a jaw-bone.

If it appear singular that the first terrestrial quadrupeds of older date than the eocene strata should have been met with in a marine limestone at the bottom of the oolite, rather than in the freshwater strata of the Wealden, where the remains of herbivorous reptiles abound, I may observe that it is not more strange than that no land shells should yet have been discovered in the Wealden, or that no pulmoniferous mollusca should have been met with, until the recent researches of Messrs. Dunker and E. Forbes had made them known in Hanover and Dorsetshire.

The last remaining point respecting the development of the more highly organized vertebrata in the older rocks, on which I propose to offer some comments, relates to the absence of Cetacea and of all marine mammalia in formations more ancient than the eocene. I agree with Professor Owen, that no argument founded on negative evidence, in favour of the imperfect development of the class of vertebrata in the earlier periods, is entitled to so much weight as the dearth of fossil cetaceans in these primary and secondary strata of marine origin. Professor Sedgwick indeed states in his recent work *, that he possesses in the Woodwardian Museum a mass of anchylosed cervical vertebræ of a whale, which he found near Ely, and which he has no doubt came from the Kimmeridge clay, because it is in the same state as other fossil bones procured from that formation. Prof. Owen, who has examined it, says that it exhibits well-marked specific characters, distinguishing it from all other known recent or fossil cetacea. If there were not drift-clay as well as Kimmeridge clay in the low region where these vertebræ were picked up, it would be a decisive indication of a marine mammal of the period of the upper oolite. It was probably derived from that formation; but the determination of its true site is not so satisfactory as could be wished, where the fossil bears on a theoretical point of such extreme importance in palæontology.

According to the 'Index Palæontologicus' of Bronn, Morren has described a Tubicinella from the chalk of Belgium; and Mr. Darwin,

* Preface to 5th Ed. of Studies of Cambridge.

on calling my attention to this fact, observes, that, if this cirripede has been correctly named, it implies with a high degree of probability the presence of Cetacea in the cretaceous sea. It is absolutely certain that a Tubicinella could live in no other way, except imbedded in some soft substance, like the blubber of whales. Not only is the recent Tubicinella invariably thus found, but all four species, in the two nearest allied genera, Coronula and Siphonicella, a new genus of Darwin, have similar habits, therefore it would be contrary to analogy to suppose that a fossil Tubicinella should have been parasitic on any class of animals except the mammalia.

But while we are waiting for more positive information on this subject, it may be affirmed that the theory of the imperfect development of the mammalia in the cretaceous or oolitic eras, is sufficiently refuted without the aid of a cetacean from the Kimmeridge clay, seeing that in the antecedent slate of Stonesfield, nature had already evolved both the placental and marsupial type of mammals. That in an age of Enaliosaurians, most of them carnivorous, the Cetacea may have been superseded to a great extent by large marine reptiles, or may have been much less fully represented than in our own era, when salt-water reptiles are almost unknown even in the tropics, is highly probable; just as wingless birds appear for ages to have predominated in New Zealand at the expense of the mammalia; while marsupial quadrupeds enjoyed a monopoly of Australia to the exclusion of the placental. Yet before we indulge even in this hypothesis, it will be prudent to wait for some years to see whether the reputed relic of a cetacean in the Woodwardian Museum is the only fossil of this class laying claims to so high an antiquity.

At the risk of appearing to repeat the caution already enjoined by me on the palæontologist, I will venture to throw out another parting hint on the subject of negative evidence. If we infer the poverty of the flora or fauna of any given period of the past, from the small number of fossils occurring in ancient rocks, we are bound to remember that it has been evidently no part of the plan of Nature to hand down to us a complete or systematic record of the former history of the animate world. We may have failed to discover a single shell, marine or freshwater, or one coral or bone in certain sandstones, such as that of the valley of the Connecticut, where the foot-prints of animals abound. But such failure may have arisen, not because the population of the land or sea was scanty at that era, but because in general the preservation of any relics of the animals or plants of former times is the exception to a general rule. Time so enormous as that contemplated by the geologist may multiply exceptional cases till they seem to constitute the rule, and so impose on the imagination as to lead us to infer the non-existence of creatures of which no monuments happen to remain. Professor Edward Forbes in his Lectures on Palæontology has remarked, that few geologists are aware how large a proportion of all known species of fossils are founded on single specimens, while a still greater number are founded on a few individuals discovered in one spot. This holds true not only in regard to animals and plants inhabiting the land, the lake, and the river, but even to a surprising number of the marine mollusca, articulata, and radiata. Our knowledge, therefore, of the living creation of any given period of the past may be said to depend in a great degree on what we commonly call chance, and the casual discovery of some new localities rich in peculiar fossils may modify or entirely overthrow all our previous generalizations, so long as they are based on the supposed non-existence at former epochs of the fossil representatives of large families or classes of plants and animals.

When we contrast the botany and zoology of primary and secondary strata with those of tertiary formations, it is more especially incumbent on us to make due allowance for a comparatively deficient acquaintance with the ancient deposits, which are more and more exclusively marine in proportion as we depart farther from those periods during which our existing continents were built up. They are more marine, not because the ocean was more universal in times past, but because, when we carry back our retrospect to epochs so distant that entire continents have been since submerged, we are less favourably placed for exploring strata thrown down in lakes and estuaries or near the shore. In studying the tertiary strata, as I before remarked, we have opportunities of becoming more thoroughly acquainted with the remains of the flora and fauna which flourished in a great variety of stations, and besides in these more modern rocks the imbedded fossils are less obliterated by the destroying hand of time. If we conceal or extenuate such circumstances when we argue with an opponent who believes that the primary or secondary fauna was as highly developed as the tertiary, we take an unfair advantage of him ; not duly conceding how much the chances of finding examples of terrestrial mammalia are on our side. "We throw with loaded dice," to borrow an expression of Dr. Fleming's, in a controversy respecting the evidences of a tropical climate at more ancient periods.

Of the tertiary mammalia, the oldest yet found, perhaps, are those of the lower eocene, occurring in the London clay of Sheppey and the sand of Kyson, near Woodbridge. Although the species are as yet few in number, the quadrumana are represented by the *Macacus Eocenus,* the marsupials by the *Didelphys Colchesteri,* the pachyderms by the *Hyracotherium cuniculus*; and these types alone indicate as full a development of the mammalia as that exhibited by the middle eocene strata of Hordwell cliff, the Isle of Wight, and the gypsum of Montmartre, near Paris, where a more numerous assemblage of species has been found. As the mollusca of the upper and lower eocene differ considerably, analogy leads us to expect that the species of mammalia of these two periods (the lower and middle eocene) will differ still more widely. On the other hand, the fossil quadrupeds of the Limagne d'Auvergne, which I refer to an upper eocene group (although some able geologists class them as lower miocene), present another fauna ; and a fourth set of mammalia belong to the era of the Faluns of Touraine. Since the falunian epoch the pliocene species came into existence, and a large part of these also have in their turn become extinct, giving place to the mammalia now co-existing with man.

If we desire to satisfy ourselves of the superior facilities we enjoy in studying the tertiary as compared to the secondary mammalia, we have only to reflect on one advantage which a collector of newer pliocene fossils enjoys over one who shall confine his investigations to eocene or miocene remains. In Owen's table of the fossil mammals of the British Isles, the longest list of species is that derived from cavern deposits. All these he refers, and I believe correctly, to the newer pliocene period. We know nothing of the bones which were enclosed in the stalagmite of caverns in the older pliocene or miocene or eocene eras ; and the same remark holds good in all those parts of France, Belgium, and Germany which I have visited, and equally so, I believe, in regard to the caves of Brazil, Australia, and New Zealand, from which the bones of extinct mammalia and birds have been derived. But if we remain so ignorant of the inhabitants of caverns in all the tertiary periods except the latest, how little knowledge can we expect to derive from a similar source respecting the terrestrial fauna, when we carry back our inquiries to the Wealden or Carboniferous epochs! We are as well assured that land and rivers then existed, as that they exist now; but it is evident that even a slight geographical revolution or transference of the position of land and sea tends rapidly to diminish our chances of learning what mollusca or mammalia may then have inhabited the land.

Yet, small as may be the progress hitherto made in deciphering the records of the tertiary periods, we seem entitled to declare that during several great revolutions in the mammalia, probably not less than five, there has been no step whatever made in advance, no elevation in the scale of being; so that, had man been created in the lower eocene era, he would not have constituted a greater innovation on the state of the animate creation previously established, than now, when we believe him to have begun to exist at the close of the pliocene.

Antecedently to investigation, we might reasonably have anticipated that the vestiges of man would have been traced back at least as far as those modern strata in which all the testacea and a certain number of the mammalia are of existing species, for of all the mammalia the human species is the most cosmopolite, and perhaps more capable than any other of surviving considerable vicissitudes in climate and in the physical geography of the globe. How far the interior of Asia, the supposed cradle of our race, may hereafter afford geological evidence of higher antiquity than can be deduced from European monuments, we have yet to learn. The observations recently made by Dr. Abich on the changes of level going on in the Caspian; the periodical oscillations of level in that sea, due principally to subterranean movements; the shifting of the position of its waters, partly by the encroachment of deltas on one side and the overflowing of the land in other directions; the buildings now seen under water while others are above the sea-level, and yet, like the temple of Serapis, having been drilled by perforating mollusks, bear the marks of former submergence—these proofs of recent changes, coupled with the evidence obtained by MM. Murchison and De Verneuil, of the vast extent of a marine or brackish-water Aralo-Caspian limestone hundreds of feet above the level of the Mediterranean, may encourage us to hope that we may hereafter be able to find a geological date for the origin of man, less vague than that which we can at present assign to the event. But so far as our interpretation of physical movements has yet gone, we have every reason to infer that the human race is extremely modern, even when compared to the larger number of species now our contemporaries on the earth.

In fluviatile deposits, such as the loess of the Rhine and the Mississippi, where the land and freshwater shells are of living species, we find no human bones or articles fabricated by man; nor in the elevated tufaceous strata near Naples, or the raised beaches of Norway, or the brackish-water strata several hundred feet high, bounding the Baltic, nor in the stratified glacial drift, in all of which marine shells are imbedded, referable, with few exceptions, to living species. I have explained my reasons for not assenting to the alleged antiquity of certain human bones, supposed to have been as ancient as the Mastodon and Megalonyx, in the loess near Natchez on the Mississippi*. In cave deposits which contain the bones of extinct quadrupeds, mixed with the remains of a small number of recent species of the same class, no human skeletons or fabricated articles have been found. There are, indeed, some few alleged exceptions to this rule, but by no means sufficiently authenticated to prove that man coexisted with an extinct mammiferous fauna; for the possibility of human remains having become subsequently mingled with those of older date, whether by natural causes or by burial in the stalagmite and alluvium of caverns, must be taken into account. In South America no less than 800 caves were explored by those indefatigable naturalists, Lund and Clausen, and they obtained the bones of 101 species of mammalia belonging to 50 genera, a fauna more rich and varied than that now inhabiting the same country. Among all these, only one species of quadruped could be identified with the recent. After ransacking so many hundred caves they met with human bones in six only, and in one of these alone were they mixed with the remains of extinct animals in such a manner as to seem to imply that they had belonged to the same epoch. In this one example, the bones are said to have been in the same state or condition as those

* See my Second Visit to the United States, vol. ii. p. 196.

of the extinct quadrupeds, the human skull being referable to the same type as that of the American Indian of Brazil. But although such fossils may have been very ancient, historically speaking, we must wait for additional testimony before we allow this single instance to convince us that the human race coexisted with the extinct Brazilian and Pampean fauna, in which case it must have outlived one assemblage of mammalia and witnessed the coming in of another, perfectly distinct*. Nor can we reconcile the facts of the case with the hypothesis that man was the exterminating agent of the quadrupeds which have disappeared. Not only have the Megatherium, Auchenia, Mastodon, and other huge quadrupeds died out since these caves were filled with fossil bones, but several also of the contemporary minute creatures, such as seven species of bats and thirty-two of Glires, and many small opossums. The five extinct apes moreover, described by Lund, were not associated with fossil bones of the living species of apes which now abound in Brazil, and in the extirpation of which man has made but little progress.

As all the vertebrate, and nearly all the invertebrate eocene fossils belong to species now no more, we could never reasonably expect the remains of man to form part of an eocene fauna. Previously to experience, the utmost that analogy entitled us to look for in rocks of such high antiquity was the occurrence of some dominant species, different from the human, yet holding a corresponding position in the then living creation. Neither the osseous remains nor the handiwork of such a being have ever been detected; and as I before stated, although there have been, since the lower eocene epoch, so many complete changes in the species of warm-blooded quadrupeds inhabiting the land, no progress whatever has been made in filling up the chasm which now separates man from the inferior animals. In that rich fauna, probably of miocene date, brought to light by the exertions of Dr. Falconer and Major Cautley, in the Sub-Himalayan or Sewâlik Hills, there are many extinct species of elephantine quadrupeds. As the living Indian elephant is more intelligent than the African species, it may possibly also be superior to all the extinct proboscidians of the Sewâlik group; but if so, how could it supply even one of those missing links in the

* For an abstract of Lund's discoveries, see Archiac, Hist. des Progrès de la Géol. tom. ii. p. 385.

chain of successive development of which we stand in need? For the superiority of man, as compared to the irrational mammalia, is one of kind rather than of degree, consisting in a rational and moral nature, with an intellect capable of indefinite progression, and not in the perfection of his physical organization, or those instincts in which he resembles the brutes.

If, therefore, the doctrine of successive development had been palæontologically true, as I have endeavoured in this discourse to show that it is not;—if the sponge, the cephalopod, the fish, the reptile, the bird, and the mammifer, had followed each other in regular chronological order, the creation of each of those classes being separated from the other by vast intervals of time; and if it were clear that man had been created later by at least one entire period—still I should have been wholly unable to recognize in his entrance upon the earth the last term of one and the same series of developments. Even then, the creation of man would rather seem to have been the beginning of some new and different order of things.

By the creation of a species, I simply mean the beginning of a new series of organic phenomena, such as we usually understand by the term 'species.' Whether such commencements be brought about by the direct intervention of the First Cause, or by some unknown Second Cause or Law appointed by the Author of Nature, is a point upon which I will not venture to offer a conjecture. That some of these species or series of vital phenomena occasionally come to an abrupt termination in our own times, as they have done in every preceding geological epoch, is no longer disputed, and the arguments of those who imagine that new creations entirely ceased from the moment that man was introduced into the globe (the destroying agencies continuing in full activity while the renovating power was suspended), appear to me inconclusive and premature. It would be presumptuous to assume that the presence of the human race upon the land could affect, still less utterly change, those laws which have governed the organic world in the ocean for millions of years; and if we enlarge our ideas respecting the antiquity of man, and concede those ten thousand or even twenty thousand years which some ethnologists demand in order to account for the early civilization of nations and the origin of their languages, we must hesitate before we affirm that such a period has been one of stagnation or diminished fluctuation in the animate world.

The identity of the fauna and flora of England and the continent of Europe requires us to assign a very distant date to the period when the existing species of animals and plants began to spread themselves over the lands we now inhabit. At the period of such migrations this island was still united with the continent, but a large number of the existing species of mollusca and some other tribes of marine animals can claim a much higher antiquity; so much so, that they were already created during the drift or glacial epoch, when the physical geography of Europe bore no resemblance to that now established. If therefore ten or twenty thousand years were added to the chronology of the human period, it would still constitute a mere fraction of that vast geological division of time during which the species now our contemporaries have been coming into existence. But how small is the progress yet made by us in ascertaining the order in which the mammalia now living were created! Some species are so ancient as to have coexisted with a fauna of which nearly all the species have died out, while others may be coeval in their origin with man, and a few perhaps are of more recent creation. Man himself has been multiplying on the earth since he entered upon it, and enlarging the range of many animals, both intentionally and against his will. These species occupy, together with the human population, the places left vacant by such as are exterminated from time to time. Whether the amount of change in those ten or twenty thousand years which immediately preceded our own times has been greater or less than the average mutation during equal periods of the past, from the Silurian to the Pliocene era, is a point on which, in the present infancy of the science, it would be idle to speculate. Of this, however, we may feel assured, that the greater the identity of the system of terrestrial changes, present and future, organic and inorganic, with that which has prevailed throughout past time, the more faithfully shall we be able to interpret the records of creation which are written on the framework of the globe.

In the first publication of the Huttonian theory, it was declared that we can neither see the beginning nor the end of that vast series of phenomena which it is our business as geologists to investigate.

After sixty years of renewed inquiry, and after we have greatly enlarged the sphere of our knowledge, the same conclusion seems to me to hold true. But if any one should appeal to such results in support of the doctrine of an eternal succession, I may reply that the evidence has become more and more decisive in favour of the recent origin of our own species. The intellect of man and his spiritual and moral nature are the highest works of creative power known to us in the universe, and to have traced out the date of their commencement in past time, to have succeeded in referring so memorable an event to one out of a long succession of periods, each of enormous duration, is perhaps a more wonderful achievement of Science, than it would be to have simply discovered the dawn of vegetable or animal life, or the precise time when out of chaos, or out of nothing, a globe of inanimate matter was first formed.

NOTE.—*Lower Silurian Reptile.*—I have not alluded in this Address to the recent discovery of the track of a quadruped imprinted on a Lower Silurian sandstone in North America. We are indebted to Mr. Logan, now at the head of the Government Survey in Canada, for having carefully determined the position of the rock containing it. The locality is the village of Beauharnois, on the south side of the St. Lawrence, twenty miles above Montreal. The rock, a fine-grained whitish sandstone, quarried for building, belongs to the group called the Potsdam sandstone by the New York Surveyors, and lies at the base of the whole fossiliferous series of North America. The markings were first pointed out to Mr. Logan by Mr. Abraham, editor of the Montreal Gazette, who appreciated their geological importance. Assuming the Chelonian origin of these foot-prints, they constitute the earliest indication of reptile-life yet known, and are not only anterior to the most ancient memorials of fish hitherto detected, but agree in date with the first known signs of well-defined organic bodies, such as Lingulæ, met with in the same rock. Professor Owen, of the College of Surgeons, has examined a slab of the sandstone, on the upper surface of which the foot-prints are impressed, together with a plaster cast of the remainder of the continuous trail, in all 12½ feet long, brought to London by

Mr. Logan; and the Hunterian Professor has had the kindness to communicate to me the following description:—

"The impressions are more numerous in regular succession than any that have been previously discovered; so that the evidence of their having been made by successive steps, afforded by this succession of corresponding prints at regular intervals, is the strongest we possess. They are in pairs, and the pairs extend in two parallel linear series with a groove midway between the two series. The outer impression of each pair is the largest, and it is a little behind the inner one. Both are short and broad, with feeble indications of divisions at their fore part. They succeed each other at intervals much shorter than that between the right and the left pair.

"The median groove is well-defined and slopes down more steeply at its sides than towards the bottom, at some parts of the track. I conclude from these characters that the animal which left the track was a quadruped, with the hind-feet larger and wider apart than the fore-feet; with both hind- and fore-feet very short, or impeded by some other part of the animal's structure from making any but short steps; that the fore and hind limbs were near each other, but that the limbs of the right and those of the left side were wide apart: consequently, that the animal had a short but broad trunk, supported on limbs either short or capable only of short steps; and that its feet were rounded and stumpy, without long claws.

"As to the median impression, that may be due either to a thick heavy tail, or to the under surface of the trunk, dragged along the ground. The shape of the body and the nature of the limbs, indicated by the above-described characters of the steps, accord best with those of the land or freshwater tortoises, and the median groove might have been scooped out by the hard surface of a prominent plastron.

"The disproportion in the size of the fore- and hind-feet is such as we find in some existing Terrapenes, e. g. the *Emys geographica.*"

R. Owen—*Letter to Sir C. Lyell, March* 18*th,* 1851.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 6, 1850.

The following communications were read :—

1. *On the* Microscopical Structure *of the* Calcareous Grit *of the* Yorkshire Coast. By Henry Clifton Sorby, F.G.S.

If a piece of that part of the calcareous grit just below the coralline oolite, which contains numerous agatized shells, be dissolved in hydrochloric acid, we obtain portions of agatized shells, and a quantity of sandy matter, which without further examination would naturally be thought to be merely sand, and such it has hitherto been considered. When however examined with a microscope, it is at once seen to contain a very large quantity of reniform bodies, which are evidently not sand, but some kind of minute organisms converted into agate. The mere occurrence of minute agatized shells in this deposit would certainly not be a fact worthy of being laid before this Society, but since they exist in such vast numbers as to constitute a very considerable portion of a well-known rock, and by the manner in which they occur are presented to us in a form that is additionally interesting, perhaps a detailed account of them will not be thought a subject unworthy of attention.

The chemical composition of a specimen containing no large shells was determined by dissolving it in hydrochloric acid; and the fine muddy matter was separated from the coarser sandy portion by suspension in water and decantation; from which I found that we had in 100 parts—

Matter soluble in hydrochloric acid, being chiefly calcareous	60
Coarse sandy matter	34
Fine sandy matter	6
	100

This coarse matter consisted, in nearly equal proportions, of the reniform agatized bodies, and sand, whose particles varied in size from $\frac{1}{100}$th to $\frac{1}{2000}$th of an inch, the average being $\frac{1}{200}$th, of which the great bulk was composed. The fine matter contained some few grains of $\frac{1}{700}$th to $\frac{1}{1000}$th of an inch, and all sizes down to $\frac{1}{100,000}$th or less, but the bulk was made up of those of from $\frac{1}{10,000}$th to $\frac{1}{20,000}$th of an inch. Hence it is clear that this deposit was not subjected to much washing at the time of its deposition, or else it would not have been composed of particles of such very varying magnitude.

Although in some parts the coarse sand and reniform bodies occur in such numbers as to touch one another; and although some portions of the grit retain their figure when the calcareous matter is dissolved away, yet in others it may be seen that a considerable part of it was deposited at the same time, and was not merely infiltrated among the coarser particles subsequently, although much of it has undoubtedly been introduced in this manner. If a thin slice of the stone be prepared, not much thicker than $\frac{1}{1000}$th of an inch, and examined with a microscope, the manner in which the grains of sand and the reniform bodies are imbedded in the impure calcareous deposit is well seen. The form of these bodies, however, is best made out by examining them as left after dissolving a portion of the stone in acid, when it will be seen that they vary somewhat in their shape. In many cases they are of a form that may most truly be termed reniform, one side being perfectly rounded, and the other having an incurved depression of varying depth, in some so slight that the body is almost globular. When turned round, they are seen to be more or less depressed, and to have an oval form, both sides being symmetrical. Their size varies from $\frac{1}{150}$th to $\frac{1}{400}$th of an inch, the average being about $\frac{1}{200}$th. Their internal structure is best seen by mounting them in Canada balsam, which, having nearly the same refractive power as the agate, causes the light to pass through them as regularly as if we had a thin section. I have also carefully investigated it by examining them in the latter condition, as occurring in a thin slice of the stone. By these means I find that they often have a structure similar to that frequently seen in large agates, the deposit having begun from the sides, and left a vacancy in the centre, which was afterwards filled up with less pure agate in alternating, more or less coloured strata. It is only in some cases that this sort of structure is well seen by transmitted light; but when a thin slice is examined by reflected light, it is seen much more frequently, owing to the circumstance that many, in which it is really present, are occupied with colourless agate, and (under the former condition) do not therefore exhibit their component layers. In some few rare instances there is a vacant space left in the centre, owing to this last stage of agatization not having occurred; and often the whole is filled with homogeneous agate. There are also cases where there is more or less of granular impurity in them, either disseminated or collected together.

But not only are these reniform bodies converted into agate, but also very frequently are entirely filled with calcareous spar. The difference between agate and calcareous spar is very readily discoverable by their action on polarized light. Calcareous spar, owing to its very intense double refraction, does not give rise to colours in the same manner as quartz or agate, in which the double-refracting power is so much less; but except when we see portions of its system of rings, the only action which it has on polarized light, is to depolarize it in some positions as white light, and by rotation definite neutral axes are found. Thus, if the whole of the reniform body is filled with calcareous spar, having the crystalline particles all arranged in one direction, by rotating it round the beam of polarized light, with the analyser in such a position as entirely to suppress it, in some positions white light will be seen to pass through the whole, while in others the body will appear entirely dark. In other cases the bodies are filled with calcareous spar, which has been crystallized in portions that have their neutral axes inclined to one another at various angles, so that by rotation, one portion is dark, whilst others are light; which by farther rotation are easily shown to be unconnected in their crystalline arrangement. When however they are filled with agate no such effect is produced, but in every position we have the appearance of a circular white disc, with black, blue and orange bands radiating in an irregular manner from the centre, and changing places by rotation. In some cases, one portion is converted into agate, whilst another is calcareous, sometimes in the form of crystalline spar, and at others as a concretion, similar to those sometimes to be seen in the substance of the shells from the grit, which are partially agatized. In these, some of the original calcareous matter still remains in the form of small concretions, sometimes disseminated in the agate, but generally attached to the sides of the shell. In the same slice, and in the same field of view of the microscope, we find some of the reniform bodies filled with agate, and others with calcareous spar, but their relative numbers vary in different parts; in some parts nearly all being agate, and in others calcareous.

I counted in the space of $\frac{1}{280}$th of a square inch, in an average portion of a thin slice, no less than forty of these bodies, and therefore on a square inch there would be 11,200; and since they are on an average $\frac{1}{200}$th of an inch in diameter, there would be at this rate about two and a quarter millions in a cubic inch. Moreover, taking into consideration those filled with calcareous spar as well as those that are agatized, I shall not be overrating them if I suppose them to constitute 20 per cent. of the whole rock. Calculating on this supposition, and on their being $\frac{1}{200}$th of an inch in diameter, and therefore about $\frac{1}{15,000,000}$th of a cubic inch in content, there would be about three millions in a cubic inch. Hence I think it may be safely considered that there are two or three millions of them in a cubic inch of the stone, when it does not contain many larger shells.

Having thus described these reniform bodies, and shown in what vast numbers they are found, I will consider what they are. First of all, they cannot possibly be grains of sand, because—

1. They are much too regular in their form, the most regularly formed grains of sand being somewhat angular.

2. Their action on polarized light is totally different from that of grains of sand; which show uniform series of colours with no radiating dark and coloured bands, and have each a definite single system of neutral axes.

3. The agate structure is quite different from that of siliceous sand.

4. Their appearance by reflected light when mounted in Canada balsam, or seen as thin sections, is milk-white, whereas sand is clear and transparent.

5. Some of them are filled with calcareous spar, which is also distinct in its characters from rounded grains of any kind of calcareous substance likely to occur in such a situation; but precisely the same as the agatized ones, except in chemical constitution.

I have had it suggested to me, that they might have been calcareous concretions, similar to the ovum-like concretions of oolite, subsequently converted into agate. They, however, do not appear to me to have been such, because—

1. They are not of the form of the ova of oolite, being too reniform.

2. Although some are more entirely calcareous, they do not exhibit the slightest trace of concretionary structure, but are filled with calcareous spar in the same manner as the chambers of the ammonites which are found in this rock.

3. They are quite distinct from the genuine concretions which may be seen in slices of the stone.

At first I thought that they might have been globular siliceous spiculæ of sponges, but after finding some which were filled with calcareous spar, I abandoned the idea; for it does not appear to me at all likely that the siliceous matter could have been removed, and its place occupied by calcareous spar.

It being of course a matter of much interest to learn whether they originally possessed shells or no, I made a thin slice of one of the ammonites which occur in the rock having its chambers filled with calcareous spar, and by examining it by polarized light, I found that where no impurity had entered there was no trace whatever of the shell discoverable, the whole of it having its crystalline particles arranged in the same direction as the calcareous spar in the interior. Where, however, there was muddy impurity in the interior, the shell could readily be distinguished. Moreover, by examining the ammonites which are agatized, I found that the exterior shell was very frequently distinguishable from the infiltered agate by being more transparent; but this transparent part was not so thick as the shell originally was, and in some cases did not occur at all. The septa, however, being much thinner than the exterior shell, could not be detected in the agate. These facts therefore show, that though we cannot detect any trace of shell in the reniform bodies which are filled with agate or calcareous spar, we are not warranted to conclude that it did not at one time exist. On this account I very carefully examined a thin section of considerable size, in order to ascertain whether there existed indications of any of these bodies having been burst in, and whether the arrangement of the impurities introduced by that means afforded evidence of the former existence of a shell.

Although such cases are rare, yet I have found some which unquestionably proved that they had been broken, and from the manner in which the impurities occur, I think that the existence of a shell is rendered very probable. In one instance the section of an agatized reniform body showed that it had been ruptured at one end, and the impurities introduced by that means into the interior are collected in such a manner as clearly to indicate the existence of a shell; a distinct uniform line or space of clear agate occurring between the outer boundary of the reniform body and the extraneous granular matter that partially occupies its interior. In another instance, a section of a calcareous body exhibits a thin layer of fine granular matter following the curvature of the inner surface of the reniform body, and lying within, and at a slight uniform distance from its outer boundary; whilst a straight elongated fragment lies within, and rests its ends against the line of granular matter. Hence it appears that both the finer matter and the larger extraneous fragment rested originally on the inner surface of a shell that has since been removed. The thickness of the shell shown by both these specimens was about $\frac{1}{7000}$th of an inch, which is so thin, that we could not expect to find any trace of it in the agate, when the septa of the ammonites are obliterated. These facts, I think, indicate that these bodies were small shells, whose interiors have been filled with calcareous or siliceous infiltrations, in the same manner as the chambers of the ammonites which are found in the rock. Nevertheless, I will not insist on this view, for I have found cases where the impurities were not arranged as though there had been a shell; but on the whole, I should say, that there is better reason for thinking them to have been shells than any other bodies with which I am acquainted. If really shells, they may perhaps have been *Foraminifera,* although I have not been able to detect any internal divisions into chambers, nor anything to indicate that they are detached foraminiferous cells, such as are sometimes met with.

Besides the reniform bodies, we find in the matter left undissolved by acid several other minute agatized organic bodies, which it may, perhaps, be as well to describe. There occur minute cellular bodies (zoophytes?), formed of more or less oval, open cells, concave on one side and convex on the other, placed end to end, and communicating at the extremities, in a similar manner to what is seen in the section of a *Nodosaria.* The cells are frequently irregular and vary much in form; two or more rows being often placed side by side; and single rows of cells frequently branch off from the main body.

Numerous spiculæ of sponges are also found, the most common of which are simple, smooth, and pointed at each end. Others are bulbed at one end, and pointed at the other; sometimes of considerable length, but usually broken. I have also found one much branched, quadrifid, with two or more of the extremities bifid.

In some sections I have observed fragments of a brown colour, apparently vegetable, and having a similar structure to portions of *Algæ*.

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2. *On the* Porphyry *of* Belgium. By Professor Delesse, Engineer of Mines, &c.

[Communicated by the President.]

The constituent feldspath of this porphyry occurs in mackled and finely striated crystals, and necessarily belongs to the sixth system. The colour of these crystals is white, or slightly greenish white, with a glassy lustre; and when of a yellow greenish colour, with a fatty lustre. As the hardness of the latter is much less than that of the white crystals, it is probable that they have been altered by infiltration and by pseudomorphosis. When of a red colour, the rubefaction has been produced by atmospheric action.

I have analysed the crystals of a slightly greenish white tint, and tolerably pure specimens, from the quarries of Quenast. They were easily separated from the somewhat darkish green matrix, the latter containing some grains of quartz. They contain—

Silica	63·70
Alumina	22·64
Oxide of iron	0·53
Oxide of manganese	traces.
Magnesia	1·20
Lime	1·44
Soda	6·19
Potass	2·81
Loss by fire	1·22
	99·69

The constituent feldspath, therefore, of this porphyry is *oligoclase*. This oligoclase, as in all porphyries, is scattered through a feldspathic uncrystalline paste, the residue of crystallization, and in which also are found all the substances that are contained in the feldspath, but in somewhat different proportions. I will designate it by the name of *feldspathic paste*. The green colour of this paste shows that it is richer in oxide of iron and magnesia than the feldspath, and this is probably to be attributed to a pseudomorphose, which would tend to transform certain portions; indeed, if the dark green portion be examined with a microscope, it is seen to be formed of small agglomerated spangles of a blackish green colour, which line the spaces left between the crystals of feldspath, as well as the irregular-shaped cavities in the rock. These spangles are microscopic, and at first sight it is difficult to determine to what mineral they truly belong; but, having extracted some decigrammes of the dark green portions from a fragment of the Quenast porphyry, I found that their loss by fire was 5·29. As we find, by microscopic examination, that these spangles are only mixed with feldspath, which, however, is found in them in a tolerably great proportion, it results therefrom that their loss by fire is still considerably superior to the proportion obtained by previous experiments made on the impure matter, and consequently these spangles are neither mica nor talc, as is admitted by many geologists. With M. Dumont, I consider these spangles, which are very soft, to be a variety of chlorite, which from its green colour, sometimes passing into black, is rich in oxide of iron, and in composition ought to closely resemble ferruginous chlorite * and ripidolith. Its matrix presents, moreover, the greatest analogy with that of the two varieties of chlorite developed in the cells of melaphyres and volcanic rocks, or in the cavities of protogines and talcy rocks.

Quartz is very frequently met with in the paste of this porphyry. M. Drapier† has observed it in dihexaëdral crystals as well as in red quartzose porphyry. This porphyry, however, does not always contain quartz, and according to M. Dumont, this is particularly the case with the variety he discovered at Hosemont; consequently, when the crystallization of the rock took place, there remained but a small amount of silex, and even this was not the case in all its parts.

In some samples, either in those of a light colour, or in those of a deep and uniform colour, there are sometimes observed flakes of amphibole and of green hornblende which are some millemetres long.

Like most porphyries, the porphyry under consideration contains, mixed up in its paste, carbonate of lime and carbonate of iron; iron pyrites is also present‡; in the Lessines porphyry there is also copper pyrites, sometimes crystallized, sometimes amorphous, in nodules of the size of a small nut; and green carbonate of copper, which is either in small veins in the porphyry, or disseminated in an earthy state in decomposed varieties, which pass into a state of clay.

Finally, there is found in it, as in all porphyries having a feldspath of the sixth system for a base, small streaks or veins formed of hyaline quartz, sometimes smoke-coloured, of green epidote, and of white spathose carbonate of lime; and, moreover, in the porphyry of Lessines violet axinite occurs, presenting the forms "équivalente" and "sous-double" of Haüy.

The epidote is here much more abundant than is general in porphyries; in the variety from Quenast, for instance, it forms a very great number of small deposits disseminated partly in the paste, partly in

* Annales des Mines, 4me série, t. xii. p. 223.

† Mémoire couronné par l'Académie de Bruxelles, t. 111. Coup d'œil minéralogique sur le Hainault, par M. Drapier, p. 18 et suivantes.

‡ Coup d'œil sur la Géologie de la Belgique, par d'Omalius d'Halloy, p. 25.

the feldspath; its crystals are microscopic, and far from clear; it has a yellow straw-colour very slightly greenish. Sometimes it is developed in a crystal of oligoclase, the form of which it preserves, taking a yellowish colour and a granular crystalline structure.

I have found that porphyry loses entirely its green colour when treated with boiling hydrochloric acid, before or after calcination; it is therefore impossible to attribute this green colour to amphibole. This results also from what has been said above.

I have ascertained the loss by fire of some samples to be—

1. Porphyry, blackish green with crystals of whitish oligoclase and a little quartz—of Belgium	1·85
2. Porphyry, a greenish feldspathic paste, with crystals of oligoclase, chlorite, quartz, and small deposits of epidote—of Quenast	1·97
3. Porphyry, a reddish feldspathic paste, containing crystals of oligoclase, deposits of chlorite forming green spots, grains of quartz, and small deposits of epidote—of Quenast	2·10
4. Porphyry, a bluish green feldspathic paste, with crystals of greenish white oligoclase—of Lessines	5·41

It appears that the loss by fire in the case of the porphyry is generally somewhat greater than that of the feldspath which forms the basis; this, as might be expected, is on account of the mixture of the chlorite; sometimes, however, as with the porphyry of Lessines (see above), the loss by fire surpasses that of the feldspath (see p. 6) by some hundredth parts, which must be attributed to the presence of a carbonate.

I have experimented, with the view of fixing approximatively the mean composition of the mass of the rock, on a sample coming from the first quarry of Lessines. It had a deep green paste in which chlorite was disseminated; its crystals of greenish white oligoclase were easily detached. A gramme of the sample, calcined and pulverized, was submitted to hydrochloric acid for twelve hours in order to ascertain the proportion dissolved in the acid; and I obtained a greyish or nearly colourless residue, its weight being 75 per cent. of that of the sample operated upon. A fourth part of the rock had been dissolved, and I found that the oligoclase had been partially attacked, for the solution contained some centigrammes of alkalies. As to the undissolved residue, it was formed of 18·50 of silica, separable by solution in potass, and of 56·50 of entirely unaltered substances.

The oligoclase of the porphyries being affected by hydrochloric acid, it is seen that the mixed carbonates cannot be exactly determined by the proportion of the bases which are dissolved in this acid, even when the rock has for basis a feldspath rich in silex like the oligoclase.

The sample of the porphyry of Lessines contained, moreover:—

Silica	57·60
Alumina and peroxide of iron	25·00
Lime	3·23
Magnesia and alkalies	9·92
Water and carbonic acid	4·25
	100·00

This porphyry is but poor with respect to silica, and specially inferior to the oligoclase which had been previously analysed : this is accounted for by the presence of the chlorite and carbonates ; besides which, the sample contained no quartz.

It is clear that the proportion of oxide of iron, of magnesia, and of lime, as well as the loss by calcination, must be more considerable than in feldspath, whilst that of alkalies is, on the contrary, less.

Although the porphyry of Belgium contains quartz, its proportion of silica is very notably smaller than that of quartzose porphyry properly so-called, which is rarely inferior to 70 per cent. ; it has a basis of oligoclase and contains no orthose, which, on the contrary, is the predominating feldspath of the latter ; consequently these two rocks differ in a very important mineralogical character.

The porphyry of Belgium, which has just been described, is met with over a small extent on some isolated points ; particularly in some slaty districts. At Quenast it forms a small hill surrounded by slaty schists, in contact with which the porphyry becomes laminated. At Lessines, on the contrary, it divides into prisms.

The geological map of M. Dumont, accompanying the work of M. d'Omalius d'Halloy on the Geology of Belgium, indicates the localities where this porphyry has been recognised ; besides Lessines and Quenast, there might be cited some other points between Enghein and Nivelles, Pitrel on the Metragne, Hozemont west of Liège, Hennurjeres south of Audimont, &c.

This porphyry is susceptible of being decomposed by the kaolinization of its feldspath, and this is particularly observed in its upper parts exposed to atmospheric action ; ultimately it is transformed into a coloured kaoline, and a yellowish brown hydro-oxide of iron, in which some grains only of quartz remain.

This porphyry, which is employed for paving, is worked in extensive quarries ; from which are obtained the paving-stones used in Brabant, in Flanders, and in the greater part of Belgium, as well as in Holland. During the last few years it has had to compete with the brown freestone of Fontainebleau. It furnishes pavements of indefinite hardness, never becoming friable like the brown freestone ; they have, however, the great inconvenience of becoming, when worn smooth, too slippery for horses.

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3. *On the* Rose-coloured Syenite *of* Egypt.

By Prof. Delesse, Engineer of Mines.

[Communicated by the President.]

The rose-coloured syenite of Egypt is formed of *quartz, orthose, oligoclase, mica,* and frequently also of *hornblende**.

The *quartz* is hyaline and grey ; it has sometimes a slight violet

* See also Lieut. Newbold on the Geology of Egypt, Quart. Journ. Geol. Soc. 1848, vol. iv. p. 340.

or smoky tint, arising, as in the quartz of protogine, from the presence of a small quantity of organic matter.

The *orthose* is of a fine rose-colour, red, or pale red, and reminds one of that of the orthose of the syenite of the Vosges, which, however, is of a much livelier colour ; it is in crystals of some centimetres in size, which are mackled like the orthose of granite rocks : this is the most obvious, and frequently the predominating mineral of the rock, giving to it its general reddish hue. Its density is 2·568. By calcination it loses only 0·35 : this loss is very slight, and such as generally takes place with orthose.

In a state of decomposition it sometimes takes a brownish colour, owing to the release of the small portion of oxide of manganese held in combination.

The feldspath of the sixth system has not the fatty lustre of that of the syenite of the Vosges, and it seems to me it ought to be regarded as *oligoclase* ; it is most frequently white ; sometimes, however, it becomes yellowish, or even greenish, as is for instance observed in some specimens from Syene, and in which it is very abundant, even more abundant than the orthose.

The *mica*, rich in magnesia and iron, occurs in bright spangles, often black, but according to De Rozière, sometimes brown or green. When black, their colour resembles that of the *hornblende*, which is often associated with the mica.

There is often present *iron pyrites*, and, as in all amphibolous granites, a little oxidulated iron.

Occasionally also, but very seldom, *garnet* occurs ; it is of a tarnished brown colour, and crystallized in the form of the *rhomboidal dodecahedron*.

I have determined, by the process described in the Annals of Mines (4th S. vol. xiii. p. 379), the proportions in bulk of the different minerals contained in a polished specimen of the rock, and have obtained :—

Red orthose	43
Grey quartz.....................	44
White oligoclase	9
Black mica	4

This specimen, which was very rich in quartz, did not seem to me to contain hornblende ; there was also less orthose present, and particularly less mica than might have been believed on inspection. This optical illusion is very general, and is to be ascribed to the circumstance that minerals which have lively and bright colours like orthose, and particularly mica, strike the eye much more forcibly than quartz, which has a grey and somewhat tarnished colour.

I have also analysed the syenite of Egypt, of which I pulverized a large piece, obtained from the Egyptian Museum in the Louvre, and placed at my disposal by M. Dubois, one of the conservators. It presented the general characters which have just been described, only that some amphibole was observed in it ; I found it to contain :—

Silex	70·25
Alumina	16·00
Oxide of iron with manganese	2·50
Lime	1·60
Alkalies and magnesia (diff.)	9·00
Loss by fire	0·65
	100·00

When the composition of this Egyptian syenite is compared with that of the syenite of the Ballons of the Vosges, it is found to approach that of the latter*. Its proportion of silex, which is 70 per cent., is indeed the same. I have already had occasion to observe, that a syenite always containing hornblende, like that of the Ballons, may afford upwards of 30 per cent. of quartz, and that its mean richness in silex may be equal to that of many granites: this shows then, that quartz is not always, as certain geologists seem to believe, merely an accessory and unimportant element of certain syenites well-characterized, like those of the Ballons. As to the proportion of alumina in the syenite of Egypt, it is shown by the previous experiment to be tolerably great, for it is only inferior by some hundredth parts to that of orthose; and this is accounted for by the abundance of the two feldspaths in the analysed specimen.

The proportion of iron must be particularly attributed to the mica and hornblende, both of which are rich in iron.

The proportion of lime, which is sufficiently great for a granite, is on the contrary very feeble for a syenite; it is also less than that of the syenite of the Ballons, which is about 3 per cent.: this results from the presence of the oligoclase and of some hornblende.

In short, the mean chemical composition of the syenite of Egypt does not sensibly differ from that found for various granites; and indeed, as I showed at the beginning, it nearly always contains much quartz. It may then be regarded as an amphibolous granite, or as a rock forming a passage from the family of *granite* to that of *syenite*.

From the interesting researches of Messrs. Russegger† and Newbold‡ on the Geology of Egypt, it results that the granite rocks occupy but a very small extent; they show themselves particularly at the cataract near Syene, and in the desert where they separate the Nile from the Red Sea, in the latitude of Koseir, about 26° N.

The syenite in particular is found half a league north of Syene, and according to Russegger, it extends a good deal to the south of the cataract and the island of Philæ into Nubia; and it is found at Elephantine and the intervening islands. From the collection of Lefevre it appears also to have been met with in the Djebel Gareb and Djebel Elzede (mountain of oil), between Koseir and Suez.

The syenite generally disappears under a brown freestone, which according to M. Russegger is again found with the same characters in Upper Egypt, in Nubia, and in Sinai. This freestone appears to

* See Annals of Mines, 4th Ser. vol. xiii. pp. 688 and 693.

† Russegger, Reisen in Europa, Asien, und Afrika, u. s. w. Stuttgart, 8vo.

‡ *Loc. cit.*

belong to the lower part of the cretaceous formation, or the Quader-sandstein: near Fatireh it is covered with a white earthy chalk, having a somewhat conchoidal fracture, that reposes on it in conformable and horizontal strata.

The quarries in which the ancients worked the syenite have been observed by all travellers who have visited Egypt; they are principally south of Syene, and between Syene and the island of Philæ. The detached blocks of the syenite, near the cataract, are sometimes of a spheroidal form, and are separable into concentric layers; according to Lieut. Newbold, however, the dry and hot climate of Egypt preserves the granite rocks much more from decomposition than the climate of India.

M. Russegger remarks, that near the cataract, the blocks found in the river, or at a small distance from it, are covered with a very thin and brilliant substance resembling black pitch. This coating, so strongly united with the rock as to be quite inseparable, is considered by M. Russegger to be oxidulated iron*.

Messrs. Russegger and Lefevre were struck by the fact, to which they frequently afterwards alluded, that the syenite of Egypt is traversed by a multitude of large veins of diorite, which is particularly the case along the cataract, near Philæ, in the neighbourhood of Syene, &c.; these diorite veins are however well known, for they also were worked by the Egyptians†.

This association of syenite and diorite is not accidental; and I have made similar observations on all the syenites that I have studied *in situ*. Indeed I could almost always find that they were associated with diorites. Thus, at the Vosges especially, the syenite of the Ballons is accompanied by diorites, which are sometimes at the bottom, sometimes on the sides of the Ballons of Alsace and Conté, forming either veins, fairly separated from the syenite and enclosed by it, or dykes uniting with and insensibly passing into the syenite.

It would hence appear, that the development of amphibole in the syenite is in intimate relation with the contents of the veins of diorite enclosed therein, and subsequently metamorphosed into amphibole.

It is, however, necessary to add, that if the syenite be generally associated with diorite, the contrary is not always the case; also, if a diorite form a vein in a granite, it must not thence be concluded that crystals of amphibole had been therein developed by that circumstance alone, and that such granite had been metamorphosed into syenite: at the Vosges, for instance, the granite is sometimes traversed by veins of diorites and yet is not amphibolous.

The Egyptians made great use of syenite; subsequently it was worked by the Greeks, and after that by the Romans. The syenite of Egypt is still sometimes employed instead of marble, and its price may be approximately estimated at 200 francs per square metre polished; it is brought as ballast by vessels trading with Alexandria, and is designated in commerce by the name of the *Eastern Red Granite*‡.

* Russegger, vol. ii. p. 321. † Ibid. vol. ii. p. 320, 322, 326, &c.
‡ Brard, Minéralogie appliquée aux Arts, t. ii. p. 241.

Great quantities of fragments of syenite are found in the ruins of all the ancient towns of Egypt; and the imagination is really tasked when thinking of the difficulties presented in the cutting, polishing, and transporting of so many gigantic monuments. The most celebrated of these ruins are, according to De Rozière, those of the isles of Philæ and Elephantine, those of Thebes, Luxor, Heliopolis, and especially of Alexandria; and although the syenite was extracted in the country surrounding Syene, yet the fragments are more and more abundant the further we descend the Nile towards the north; which is to be ascribed, as M. de Rozière has shown, to the fact that the seats of government successively approached the Mediterranean, and that the requisite material for the numerous sacred and palatial structures was wanting in that northern region of Egypt which is essentially calcareous and gravelly.

The syenite was of all rocks the one preferred by the Egyptians, and they employed it for the construction of their most remarkable monuments; of these monuments there might be cited the obelisks, the sphinxes, the sarcophagi found in all parts of Egypt, Pompey's Pillar and Cleopatra's Needles, at Alexandria, both the inside and outside of the great pyramid of Cheops, and particularly the monolith sanctuary of Sais. At Paris may be seen one of the Luxor obelisks, and in the Egyptian Museum at the Louvre, the feet and head of a colossal statue of Amenophis III., as well as a great number of sculptures, which under the ever-pure sky of Egypt, for the greater part have not suffered any alteration, even perfectly preserving their polish, for nearly 4000 years.

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4. *The* Slaty Rocks *of the* Sichon, *or Northern end of the Chain of the* Forez *in* Central France, *shown to be of* Carboniferous Age. By Sir Roderick Impey Murchison, G.C.St.S., F.R.S., G.S., L.S., Hon. Mem. R.S. Ed., R.I.Ac., Mem. Imp. Ac. Sc. St. Pet., Corr. Mem. Ac. France, Berlin, Turin, &c. &c.

Long as the tertiary lacustrine deposits and extinct volcanos of Central France have been explored and described, the true geological age of the more ancient and crystalline rocks which form the margin of that remarkable area have not yet been adequately developed. The few observations I was enabled to make last summer, when a visitor at the baths of Vichy, and of which I now give an account, will at all events be sufficient to show how little acquainted we have hitherto been with the age of the rocks that constitute the eastern boundary of the Limagne d'Auvergne. At the same time let me do justice to the author, who in the 'Mémoires pour servir' has well described the mineral structure of the tract to which I invite attention, and has laid down the general outline on the geological map of France*. The same district has also been specially dwelt upon by M. Visquenel,

* M. Dufrenoy. See Mém. p. servir, vol. i. p. 260 *et seq.*, and Carte Géol. de la France.

in the Bulletin of the French Geological Society *. But near as it is to the much-frequented baths of Vichy, no one had previously discovered the organic remains to which I shall presently advert, and which enable us for the first time to assign the old rocks in question to their real place in geological history. In making this announcement I would however state, that organic remains are so scarce, and the rocks containing them have so much an "azoic" aspect, that I would rather attribute my discovery of fossils to a happy accident, than pretend to throw any discredit on my precursors.

The lacustrine limestones and marls of the Limagne d'Auvergne are prolonged northward by Vichy and Cusset to Billy, on the right bank of the Allier, about twenty-five miles south of Moulins, where they constitute hills of some hundred feet in height, the horizontal strata of which stand out to the low, flat, and younger region of the Bourbonnais and Orleanais, without any barrier or edge whatever of older formations.

In the hills east of Vichy, however, and near Cusset, the lacustrine limestone is flanked by schists penetrated by porphyry and other intrusive rocks, which form the northernmost extremity of the chain called the Forez. Both these classes of rock are well exposed on the banks of the small river Sichon, above Cusset, where their outlines present a picturesque gorge daily frequented by parties of pleasure from Vichy. In ascending the Sichon from Cusset, the first prominent objects are bluff porphyries, which jut out through the verdant slopes and rise above the rich and umbrageous walnut-trees of this pretty sinuous valley. These porphyries, for the most part quartziferous, are of red, pink, and dark grey colours. In some of them the crystals of felspar are so large as to liken them to the Norwegian 'rhomb-porphyr' of Von Buch. In parts, however, the porphyry passes into and becomes a coarse-grained greenstone, which is largely quarried, and in other places into a compact felspar rock or claystone. On the whole, these bosses are void of anything approaching to stratification, and are traversed by innumerable cross fractures and fissures. They are indeed manifestly intrusive, as respects the schistose strata with which they are associated; for in numberless places the latter are seen to be irregularly broken through and cut up into wedge-shaped masses which are isolated in porphyry.

The schists have on the whole a direction from S.S.E. to N.N.W.; but the strike is very devious, owing to the above-mentioned intrusions; whilst the strata dip at every possible angle from verticality downwards. The schist resembles some of the older palæozoic strata of the British Isles which have been much affected by igneous eruption. Its aspect led me at first to suppose that it might prove to be of Lower Silurian age. In parts it is affected by a rude slaty cleavage, as indicated by coarse and irregular planes of fracture transverse to the laminæ of deposit. These, and the predominance of joints, the faces of which are coloured red by oxide of iron, occasion the stone to break into multitudes of small rhombs. In such a rock—even in

* Visquenel sur les environs de Vichy. Bull. Soc. Géol. Fr., 1st ser. vol. xiv. p. 145.

Insert opposite Page 15. Part I.

M. de Verneuil, having re-examined these fossils just after the opposite page was printed off, has made the following alteration and addition :—*for* Bivalve, resembling the ***Pleurophorus costatus***, King, *read Solenopsis*, M'Coy,—and *add*, a second species of *Productus* —small, and striated longitudinally. [R. I. M.]

those portions of it where the schists are less shivery, and where they were formerly quarried for (imperfect) roofing slates—it seemed hopeless to search for fossils. On one of the summits, however, of the plateau on the right bank of the Sichon, and about two miles to the south of the spot called the "Croix de Justice," I observed courses of an earthy yellowish sandstone—not unlike some British varieties of plutonic ash or volcanic grit—interlaminated with the schists, in which I detected the remains of *Encrinites*. This led me to re-examine on a subsequent occasion the schists of the valley of the Sichon removed from the spots where they are most interfered with by the porphyries, and by which in fact they have in some places been so considerably metamorphosed as to part with their lamination and become amorphous. On the right bank of the stream, to the south of the abandoned "Ardoisière," or slate quarry, I further perceived highly inclined and vertical bands of pebbly conglomerate, subordinate to the schist. This pudding-stone contains dark and light coloured, small, rounded pebbles of schist, quartz, and a little limestone in a grey matrix, and might well pass for an intercalated conglomerate of the Silurian or Devonian systems.

Taking simply into consideration the mineral structure of the slaty schists, their purple plum-coloured exterior, and their fracture, combined with the aspect of the sandstones, grits, and conglomerates, few geologists, indeed, would hesitate to say that they formed part of what was called the old greywacke series. This inference might be further sustained by two courses of limestone which I discovered, the one of two feet, the other of about nine feet in thickness; this rock being hard, of scaly fracture, and of light grey or bluish colour.

Not far, however, from these calcareous courses I procured some fossils, after a long search, in the thin layers of half-rotten, slightly ferruginous schist. These having been subsequently examined at Paris by M. de Verneuil, have proved to be—

Productus fimbriatus, Sow., or a form with spines on the transverse ribs undistinguishable from that species.

Chonetes papilionacea? Phill.

Orthis crenistria, Phill.

Bivalve, resembling the *Pleurophorus costatus*, King.

Univalve shells in fragments.

Phillipsia—*i.e.* the pointed buckler and cheek of this trilobite.

Encrinites of two species.

Now (to say nothing of the carboniferous forms of *Chonetes* and *Orthis*) as no spinose *Productus* like the *P. fimbriatus*, nor any species of the genus *Phillipsia*, have ever yet been found in the Silurian or Devonian systems, there can be no doubt that these schists of the Sichon, ancient as they look, and as indeed they have hitherto been considered, must now be viewed as really belonging to the carboniferous system; and that the intrusive porphyries of this tract were erupted after their deposition.

Having thus satisfied myself concerning the rocks in the lower part of the valley, I next sought to connect them with the higher elevations of the chain of the Forez from which the river Sichon descends. Whilst on a visit to the ancient castle of Busset, where I was hospitably entertained by its noble possessor*, I found that the plateaux on both banks of the Sichon were penetrated by numerous bosses of trap rock. Porphyries of different character, some of them very granitoid, are seen in contact with highly jaspidified and altered schists. In the whole ascent of the river to Ferrières, numerous minor domes of porphyry appear, which have thrown the strata into such numberless flexures, and have so dislocated and wrenched them in divergent directions, that all regularity of strike and dip is obliterated. To search in such a district for any order of formations was impracticable; but I came away disposed to think, that the marble limestone (once partially worked) at Ferrières was a mere repetition of the less altered calcareous courses near the Ardoisière of Cusset. I could detect no marked change in the aspect of the rocks, and the carbonaceous black schists which had been dug into in search of coal, further led me to suppose, that the same formation was continued into the higher parts of the Forez by repeated undulations.

An excursion along the western edge of the Forez to the flourishing manufacturing town of Thiers confirmed this view. That town is built on a steep rocky slope facing the plain of the great Limagne d'Auvergne, and is watered by a rapid torrent which descends into the valley by a picturesque, deep gorge. There again we have (particularly under the lofty church of St. Gené) the very same phænomena that occur all along the banks of the Sichon, thirty miles to the north. At Thiers, indeed, the features are grander. Like the Scottish varieties of porphyry of Loch Fyne, and other places, some of the intrusive rocks of the Forez may almost be termed granites; others are fine-grained and pass into greenstone. As to the schists which they penetrate, it is impossible to distinguish them from the similarly broken strata of the Sichon, except that, if possible, these of Thiers are still more altered.

I further endeavoured, by a traverse across the lacustrine deposits to Gannat, and thence by Ebreuil, to the beautiful castle of De Veauce†, to detect if possible something of organic life in the ancient schists (thrown off by the granite) which form the western boundary of the great trough of the Limagne d'Auvergne. But I had little time at my command, and I must leave to other observers the credit of detecting fossils, if such there be, in the schists, whether argillaceous or micaceous, which range southwards from Ebreuil, by Pont Gibaud, into the region of M. Dor and the Cantal. I satisfied myself, however, in an excursion westwards, that many of the beds of the coal-field of St. Eloy, near Montaigu, are made up out of the detritus of still older schists and their quartz veins. I am unprepared to say positively whether this coal tract, as well as other numerous little coal deposits that extend along the western side of the M. Dor into the Cantal (and which I examined in company with Sir C. Lyell in the year 1828), are or are not of the same date as the carboniferous schists of the Sichon; but I am disposed to think that

* Général le Comte de Bourbon-Busset.

† The seat of the Baron De Veauce.

they constitute an upper member of the same group. At all events, the highly dislocated positions of the former, and the manner in which they are wedged in among more ancient rocks, indicate that the great porphyry eruptions, to which allusion has been made, took place subsequently to their accumulation.

In the meantime, the discovery of the above-mentioned organic remains in the schists of the Sichon has enabled us to assign to one of the great flanking ridges of the Limagne d'Auvergne, a much more recent age than that to which its rocks had previously been referred. We now see that the fundamental strata of the Forez are, in fact, of precisely the same epoch as those of the adjoining and parallel chain of the Tarrare, which is interposed between the region now under consideration and the coal-fields of St. Etienne and Lyons. The French geologist, M. Grüner, had discovered in adjacent parallel tracts, and notably at Regny, two leagues east of Roanne*, a certain number of fossils which M. Voltz and himself had classed as Silurian, but which M. de Verneuil has assigned to the carboniferous system†. Just as on the Sichon, these fossils occur in schists more or less metamorphosed, and occasionally very crystalline, which, like those of the Sichon, are also much penetrated by porphyry.

The occurrence of mountain limestone fossils in strata of such an antique and crystalline aspect, and which, being in the highest degree dislocated and inclined, are stated by the French geologists to be unconformable to certain overlying coal-fields of France, determines a question of deep interest to the physical geologist and palæontologist. Assuming that this unconformity exists, it follows that there must have been a powerful disruption of the older members of the carboniferous series (*i. e.* of strata of the age of the mountain limestone with its shales and sandstones) before the overlying coal-bearing deposits were accumulated.

The proofs of a conformable collocation in Franconia of Silurian, Devonian, and lower carboniferous strata, as formerly adduced by Professor Sedgwick and myself‡, were doubted by an eminent French geologist §, simply because the adjacent coal-fields of Bohemia had not partaken of the same movements of upheaval. Hence it was surmised that the limestones of Hof, though containing numerous large *Producti* identical with species well known in Britain (and which induced my friend and self unhesitatingly to consider this rock true carboniferous limestone), could not really be carboniferous, but must belong to an earlier æra. Again, the very decisive testimony obtained by M. de Verneuil from the limestones of Sablé and its environs was doubted, in spite of a profusion of true carboniferous types, by those who, classifying rocks by signs of physical dislocation, could not then be induced to believe that so great a movement could have occurred

* See Annales des Mines, vol. xix. p. 80, 3rd ser.

† M. Jourdan has proved by his fine collection of fossils, that these carboniferous strata extend from the Saone to the Loire and Allier. See Procès verbaux de la Société d'Agriculture de Lyon, vol. i. 2 série, p. 67.

‡ See Trans. Geol. Soc. Lond. New Series, vol. vi. part 2. p. 298, pl. 23. fig. 15.

§ M. Élie de Beaumont.

in the middle of that which geologists have termed the carboniferous system.

M. de Verneuil has recently acquainted me, after an examination of the succession of palæozoic deposits in the department of the Sarthe, that he does not now believe there is any coal in the widely developed Devonian tracts of that region. The uppermost member of those Devonian rocks or limestones, loaded with fossils, is surmounted by sandstones, schists, and beds of anthracite (Viré, Sablé, &c.). The limestone, into which these graduate, contains the *Productus gigas, Chonetes comoides,* and many other well-known forms; and this rock is covered by other schists also anthracitic. Now, these carboniferous schists, sandstone, and limestone, are perfectly conformable to the inferior palæozoic rocks, viz. Devonian, Upper Silurian, and Lower Silurian; although according to geologists they are all unconformable to the overlying coal-field of St. Pierre la Cour. It is this break under the coal which, according to M. Elie de Beaumont, accords with the elevation of the "*Ballon d'Alsace*."

The accumulation of clear fossil evidence from various regions will I trust now prevail, and induce all geologists to admit, that the distribution of animal life and the chronology of ancient races by no means accord with the former physical revolutions of the surface. Thus, there is no zoological change more complete and absolute in the whole succession of deposits, than that which is seen when we examine the summit of the palæozoic rocks, or Permian system, and compare its contents with those of the overlying Trias*; and yet in every well-known tract of Europe, these two deposits are conformable, though their imbedded animals are *toto cœlo* distinct. On the other hand, whilst many of the Permian *Producti* approach closely to carboniferous types, there has been in many countries a great break between these two deposits.

In Britain there has been no general severance between the lower and upper members of the carboniferous series; and hence we possess a very full and copious development of all its middle portion. We now further learn why the representative of that portion is absent in some tracts of France, and all those parts of the Continent where nature's deposits have been interrupted. There, after a deposition of lower carboniferous strata, powerful outbursts of porphyry and other igneous rocks took place, occasioning a great dismemberment of the pre-existing formations, and occupying that time which in more quiet regions was spent in the tranquil accumulation of strata (such as the millstone-grit, &c.) which underlie the great supplies of English fuel.

Referring then to data I have previously furnished, to prove that no fractures in the crust of the globe are so general as to constitute a true groundwork of classification, I offer this contribution from the banks of the Sichon in support of my views.

* See Russia in Europe and the Ural Mountains, vol. i. p. 204.

November 20, 1850.

George Edward Gavey, Esq., and Dr. James Macfadyen, were elected Fellows. Prof. B. Studer and Prof. Hermann von Meyer were elected Foreign Members.

The following communications were read:—

1. *Notice of the occurrence of an* Earthquake *at* Brussa.

[Communicated from the Foreign Office, by order of Viscount Palmerston.]

On the night of the 19th April, 1850, at half-past eleven p.m., a shock of considerable violence occurred at Brussa, in Anatolia, lasting from eight to ten seconds. The oscillation seemed to proceed from S. or S.W. This was followed by two other shocks during the night, and by four others at intervals up to the 21st, all comparatively slight. The same earthquakes were felt throughout the country as far as Kiutahiyah, particularly at Muhelitsch (forty miles W. of Brussa), at Lubat, on the Lake Apollonia, and at Kirmasli (forty miles S.W. of Brussa), on the south side of the lake, at which latter place there was a temporary gush of water and sand from an opening in the earth. It was noticed that the strongest shocks followed shortly after heavy storms of hail, and also that at Zehekerghé, near Brussa, a momentary stoppage of the mineral springs accompanied the earthquake.

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2. Generalizations *respecting the* Erratic Tertiaries *or* Northern Drift, *founded on the Mapping of the* Superficial Deposits *of a large portion of* Norfolk. *With a Description of the* Freshwater Deposits *of the* Gaytonthorpe Valley; *and a Note on the* Contorted Strata *of* Cromer Cliffs. By Joshua Trimmer, Esq., F.G.S.

In exhibiting to the Society a map of the variations of soil over a considerable portion of Norfolk, by which the dependence of those variations on contours is shown, I avail myself of the opportunity to communicate a brief outline of the conclusions to which I have been led, respecting the erratic phænomena, by a very minute examination of a district where they are well exhibited, and where their place in the geological scale of time is well defined.

These variations were laid down by me, during parts of the years 1844, 1845, and 1846, on the Ordnance Map—a work which was undertaken as the basis of a paper on the Distribution of Soils, written for the Journal of the Royal Agricultural Society*. In that paper I confined myself, as much as possible, to subjects having a practical agricultural interest; reserving others of a purely geological character for publication in some scientific journal. They were embodied, at the request of Sir Henry De la Beche, in a memoir which

* Vol. vii. part ii.

I prepared in the beginning of 1847, for the Memoirs of the Geological Survey of the United Kingdom; in which the erratic tertiaries of Norfolk were compared with a small portion of those of South Wales, which I had mapped, during part of the preceding summer, for the Government Geological Survey. As various unexpected circumstances have delayed the publication of that paper, and as I understand there is no prospect of its appearing at present, I am desirous of now placing on record its principal generalizations so far as regards my work in Norfolk, before I joined the Geological Survey, referring to that memoir, when published, for details.

Those generalizations are—

1. That our views of the glacial or erratic period are very incomplete if we consider its deposits merely as a formation, which lay for ages beneath a sea, through which icebergs, straying from northern regions at the same annual average rate as at present, dropped their loads of foreign detritus, here and there, until the floor of the ocean became thickly strewn with boulders, as seen in the regions of Europe and America now covered by the erratic tertiaries or northern drift. Such views are incomplete, because our own island affords the means of fixing the precise point from which the commencement of the glacial period dates, and of proving that Britain sank as well as rose during that period. These proofs consist in the forest of Happisburgh and Cromer buried beneath the erratic tertiaries, as first described by Taylor and Woodward; and in the circumstance that on the western coast the northern drift, with its marine remains, has penetrated into Cefn Cave, and, by its superposition to the deposits containing mammalian remains, testifies, like the buried forest, to the presence of a subaërial surface immediately before the transport of northern blocks.

2. The date of this subaërial surface was subsequent to that of the mammalian crag, on which are rooted the buried trees of Happisburgh and Cromer; and whatever indications the faunæ and floræ of the red and mammalian crags may afford of an approach to an arctic climate, the true glacial phænomena of transported blocks do not commence, in Britain at least, until during the submergence of the desiccated and tree-bearing surface of the latter.

At the commencement of that submergence, a bed of marine shells at Runton, *in situ*, above the fluvio-marine deposit on which the forest stands, testifies to marine conditions not very dissimilar from those of the crag, quickly succeeded by the peculiar phænomena of the till or boulder clay, with its broken shells, erratic boulders, scratched and subangular detritus, and masses of fragmentary chalk, unabraded and unmixed with other matter, in a manner very difficult of explanation, if the transport were not effected by means of some buoyant material. At Mundesley the early part of the submergence is marked by the interlacing of peaty mud and freshwater shells with the till, as described by Sir Charles Lyell*, and attributed by him to the entry of a river into the sea at that point.

3. The erratic deposits form continuous sheets of strata, more ex-

* London and Edinburgh Phil. Mag. 1840, vol. xvi. p. 353.

tensive than any other tertiary deposits of Britain, although in some localities they have been much interrupted by denudation.

4. They occur under the form of an upper and a lower deposit, possessing certain common characters, and certain others that are distinctive. Boulders transported from a distance are found in both; but the lower erratic tertiaries deviate more from the type of other tertiary strata than the upper erratics.

5. The lower deposit or boulder clay was a littoral deposit of an arctic climate, which advanced southwards during the subsidence of the land, and retreated northwards during its subsequent elevation. An examination of the soundings recorded in the Polar Voyages, particularly those of Sir Edward Parry, proves that in frozen seas mud, which, under ordinary conditions, is regarded as a deep-water deposit, is characteristic of the vicinity of land, where sand and shingle would prevail in other seas.

6. The position of the lower erratic tertiaries in the valleys proves that the latter were excavated previous to the subsidence of the glacial period, and indeed before the epoch of the mammalian crag; so that the general configuration of the land was nearly the same, during the ante-glacial subaërial period, as at present; old excavations having been filled during the process of subsidence, and re-excavated, more or less, during the period of re-elevation.

7. The distribution of foreign matter in the erratic tertiaries of Norfolk is such as would have resulted from the action of shore-ice on sinking land; the ice being sometimes fixed to the coast for months, and even years together, and sometimes in daily rapid and capricious motion, produced more by winds than by tides (see the Polar Voyages); the local action being modified, and the local and foreign detritus blended, by a constant general current from the north. The prevalent lines of transport in Norfolk are from the north-east and from the west. Scandinavian erratic blocks are more abundant on the eastern side of the watershed and the borders of the German Ocean, while blocks and small detritus of oolitic rocks, increasing in quantity westward along certain lines, indicate that quarter as their source. They appear to have travelled chiefly along the valleys of the Waveney and Little Ouse, which flow eastward and westward from sources within a few yards of each other.

A very slight depression would convert these valleys into a strait, communicating with the Wash and insulating the greater portion of Norfolk. But, although the general lines of transport have been from the north and west, there is an occasional intermixture of detritus borne in opposite directions under the combined influence of the shore-ice, acted on chiefly by winds, and the changes of the configuration of the surface,—valleys, as the land subsided, having been converted into straits and friths, and hills into islands and promontories. Near the heads of valleys, the boulder clay consists almost wholly of materials derived from the bounding rocks; while nearer their mouths, it is much mixed with detritus derived from a distance.

8. In the upper erratic tertiaries the phænomena of ordinary marine action are more prevalent than in the boulder clay; the gravel

is more rolled, the stratification more decided; scratched fragments more rare, if not entirely wanting; while false bedding indicates the pushing action of water, in seas of no great depth. The deposit, however, still furnishes some erratic blocks and several beds of unmixed and unabraded chalk, indicating the action of floating ice. This difference in the character of the upper and lower erratics may arise, in part from the former having been deposited in a more open sea, and in part from the mitigated rigour of the climate, particularly during the deposition of the more recent portions of the upper erratics.

9. The contortions in the strata of Cromer Cliffs, which have been referred to various causes, and among others to the ploughing up of the bed of the sea by icebergs, appear susceptible of a better explanation by supposing masses of ice fixed in the boulder clay, which, as the coast subsided, became covered with laminated clay and thin alternating beds of sand and gravel (see *infra*, p. 30, and Diagrams, figs. 3–5). As the ice melted, on the return of a milder climate, these beds of clay, sand, and gravel would subside into the cavities left in the till. When the area of the ice was extensive compared with its depth, the result would be merely a slight curvature of the strata above the till. When the thickness of the ice was considerable compared with its area, the subsidence of the strata above it, combined with the collapse of the walls of till bounding the cavity, would produce every variety of contortion seen in the Cromer Cliffs. The difficulty of fixing buoyant ice under water is no objection to the hypothesis; for the records of the Polar Voyages give to ice so fixed the character of a *vera causa*. Sir Edward Parry found for miles along the coast, near Melville Island, a dark blue stratum of solid ice imbedded in the beach, at the depth of 10 feet under the surface of the water. "The ice," he says, "had probably been the lower part of heavy masses forced aground by the pressure of the floes from without, and still adhering to the viscous mud of which the beach is composed after the upper surface has in the course of time dissolved."

10. The different elevations at which the boulder clay occurs on the coast and in the interior are in accordance with the theory of the gradual advance of an arctic littoral deposit over subsiding land, now restored by re-elevation to about its former level; and the theory will explain the transport of large blocks from lower to higher levels. On the eastern coast, where the united thickness of the upper and lower erratics has been estimated at between 300 and 400 feet, that of the boulder clay rarely exceeds 80 feet, varying not unfrequently to 10 feet; while at Swaffham it has been ascertained that a little below the summit of the watershed it fills a hollow in the chalk to the depth of 90 feet; and on the actual summit the upper erratics, which are so thick on the eastern coast, rarely attain a thickness of 30 feet, and are generally much thinner, usually resting on the chalk, but occasionally on patches of till in its hollows.

11. While the eastern side of Norfolk best exhibits the history of the erratic tertiaries during the period of depression, their history during the period of elevation is best traced on the western side. On

the outcrop of the secondary strata on the west, the declivity of the surface on which the erratic tertiaries rested has been greater, and their denudation more complete.

Patches of boulder clay occur at the commencement of the descent from the summit level to the estuary of the Wash; but in general it has been wholly removed on the declivity, and the reconstructed materials of the upper erratics have been brought down to lower levels, during the process of upheaval, where they are in immediate contact with the secondary strata. Till, in the form of blue clay containing fragmentary chalk, has been found underlying the alluvial deposits at Lynn and Denver Sluice.

12. At an elevation of about 30 feet above the level of the Wash we have the older estuary deposit of the valley of the Nar, described some years since by Mr. Rose*, with its marine shells all of existing species (though not the same group as that of the marine alluvium of the marshes and of the existing estuary) associated with bones of the horse, elephant, and rhinoceros. I have the authority of Mr. Rose for stating, that while he still adheres to the statement in his paper, that the Nar clay is not anywhere covered by deposits containing blocks transported from a distance, he has found situations where it is overspread with loam and gravel, containing flints of such a size as to indicate considerable force in the currents which transported them.

13. In the neighbouring smaller valley of Gaytonthorpe, at a somewhat greater elevation, are some deposits of which a detailed description will be given in the sequel. The most remarkable feature of these deposits is, that, amidst a general absence of organic remains, one of the sections exhibits freshwater strata with mammalian teeth, resting on a variety of the boulder clay; and that pipes and furrows have been formed in the freshwater deposits, similar to those in the chalk which have so long attracted the attention of geologists.

14. In other communications to the Society, I have assigned reasons for ascribing these pipes and the furrows of which they form the termination to the mechanical action of water, before the matter filling them was deposited. This action appears to have been in operation from the commencement of the eocene to the close of the erratic tertiary period. In Kent, many of the pipes and furrows in the chalk are filled with eocene sand. Those in the tilted chalk of Alum Bay are also filled with eocene sand; and they have the whole argillaceous mass of the mottled and London clays above them,—an important fact in favour of the origin which I assign to the cavities.

Near Norwich they are filled with mammalian crag. In other parts of Norfolk they are filled sometimes with that, sometimes with the loamy deposit which constitutes the soil, and which I call the Warp of the drift, or erratic Warp. I have sections exhibiting the two classes of phænomena in the same pit. The last fills similar cavities in whatever beds have been exposed by denudation, so as to constitute the subsoil, whether they be beds of transported and reconstructed chalk in the upper erratics, or the boulder clay of the lower erratics,

* London and Edinburgh Phil. Mag. 1836, vol. vii.

or the chalk itself, or beds of gravel and sand; though in these last two they are not so regular and distinct as in the more consolidated beds.

15. If I am right in my views of these being due to the mechanical action of water, and in identifying the deposit which fills them, in the case of the Gaytonthorpe freshwater beds, with the Warp,—a surface-soil, filling similar cavities in all subsoils, and at all elevations, up to the summit-level of Norfolk, which is about 600 feet*,—and if the surface-soil be, as I contend, an aqueous deposit of some kind or other, it follows that these aqueous operations took place subsequently to the denudation of the upper and lower erratics, after a sufficient interval had elapsed to permit the accumulation of from 10 to 20 feet of freshwater deposits; and it becomes an interesting subject for future investigation, to trace the nature of the aqueous operations by which the soil was produced.

16. On the other hand, if these phænomena at higher levels resulted from the last wash of the glacial sea, during the emergence of the land, and are distinct from those at Gaytonthorpe, it is an inquiry no less interesting and essential to the right interpretation of the history of the closing operations of the erratic period, where it is just passing into that of the modern alluvium, to determine the true nature of the Gaytonthorpe cavities.

17. The general absence of marine remains from the upper erratics of Norfolk, and the general absence of regular beds of these remains from both upper and lower erratics in every district which I have examined,—and I have now examined many in England, Wales and Ireland,—are remarkable facts, and although perhaps referable, in part, to causes not peculiar to the glacial period, we must not forget that an extreme paucity of shells constitutes one feature of Polar seas.

In Sir E. Parry's 'Voyages' we read occasionally of shells and sand accompanying stones on the "dirty ice;" and we have occasional mention of shells and corals brought up by the dredge; but attempts to procure shell-fish in sufficient quantities to afford a meal for the crews invariably failed. The most varied and extensive haul is recorded by Captain Beechy in Behring's Straits; but, on the other hand, we have the following notice in Sir John Franklin's first Voyage: "On the spot where we landed were some mussels and a single piece of sea-weed. This was the only spot on the coast where we found shells."

18. The amount of denudation to which the erratic tertiaries have been exposed varies in different parts of Norfolk. It is least in the northern portions, where the lower erratics have been scarcely reached; greater in South Norfolk and in the north of Suffolk, where the boulder clay is very generally exposed, the upper erratics occurring only as outlying masses, and where the lower erratics have been cut through, in some parts, as along the valley of the Waveney, down to the crag and the chalk. The denudation is greatest of all on the west, where

* I believe the recent triangulations of the Ordnance Survey have considerably reduced this; the former vertical angles having been taken with very inferior instruments.

the upper and lower erratics have both been very generally removed, and the secondary strata are covered with thin accumulations of their reconstructed materials, brought down to lower levels.

19. The variations of soil and subsoil are caused by this varying amount of denudation, combined with the varying thickness and composition of the Warp, the former being the result of levels and contours, the latter of the composition of the neighbouring and subjacent beds exposed to denuding action. For details I refer to my Map of Norfolk*, and to the paper on the Distribution of Soils, in the Journal of the Royal Agricultural Society of England, vol. vii. part ii. 1847.

20. Although the boulder clay extends to the northern confines of the valley of the Thames, I have seen no trace of it south of that river, nor have I met with any boulder, except one of trap which was in the upper part of the elephant bed at Brighton, a deposit which much resembles the upper erratics of Norfolk. The superficial deposits of Hampshire, Sussex, and Dorsetshire consist of flint gravel, unabraded or very slightly abraded, of little depth, rarely exceeding 30 feet, and often much less, very generally spread over the surface at all heights, from about 600 feet on the summit of some of the chalk hills, down to the sea level. The highest beds contain the largest flints and the least abraded. They appear to diminish in size with the different stages of descent; and it is a remarkable fact, that they are in general little more waterworn at the lowest than at the highest levels. I consider this gravel to be a modification of the upper erratics of Norfolk, the region south of the Thames having been, perhaps, the last submerged, and having continued the shortest time under water. I have found neither shells nor mammalian bones in this gravel throughout the Hampshire eocene district, west of the Southampton Water, nor could I hear of any having been found. The local papers have, however, very recently announced the discovery of tusks of the elephant and horns of the stag in beds connected with this gravel, in the grounds of Lord Eldon at Encombe.

21. With regard to mammalian remains, I believe that we have two elephantine groups, one preceding the submergence of the erratic period, and the other inhabiting the country at the close of the period of elevation. To the former are to be referred the mammalian crag and the remains of the bone-caverns in general;—to the latter the freshwater beds of the valley of the Thames, of the Avon in Worcestershire, of Gaytonthorpe, and of Bielbecks in Yorkshire, together with the marine deposit of the valley of the Nar.

22. In the valley of the Thames there are two deposits of brick-earth and gravel; one containing mammalian bones, with land and freshwater shells identical with species now inhabiting the neighbourhood; the other destitute of them. The former are only found in the vicinity of the Thames and its tributaries, and at certain heights above them; the greatest distance at present known being about a quarter of a mile, and the greatest height above the present stream about 40 feet. These fluviatile deposits of gravel, sand, and loam are

* The map does not accompany this paper.

covered by others, in which a careful search, continued for many years by my relation the late Mr. William Trimmer, in the numerous brick-fields and gravel-pits opened in them, detected no fossils. The upper or non-fossiliferous deposits of the low grounds extend over the higher districts, ranging south of the Uxbridge Road, by Ealing, Hounslow, Heston, Norwood, Southall, Drayton, Harnondswirth, and Cowley. The lower deposits, and consequently the upper, appear, by the evidence of the granitic and other foreign detritus, recently collected at Brentford by Mr. Morris, to have been formed subsequently to the denudation of the erratic tertiaries. I should refer the upper or non-fossiliferous deposits to the period of the Warp in Norfolk; and, if my views on this subject be correct, it becomes an interesting question for future investigation, whether the agencies which produced these upper deposits had any connection with the disappearance of the great mammals.

23. At the same time that I think we have evidence of nearly the whole of England being submerged during the erratic period, it is by no means improbable that both subsidence and re-elevation commenced from the north; so that the district south of the Thames, connected, perhaps, at that time with the Continent, may have remained above water when Norfolk was submerged; and portions of Norfolk and of the still higher regions north and west of it may have emerged while Dorsetshire, Hampshire, and Sussex remained beneath the sea. Portions of the desiccated bed of the glacial sea may have connected the emerging northern districts with portions of the Continent which escaped the glacial submergence, and may thus have afforded facilities for immigrations of colonies of plants and animals which had been driven southwards during the period of subsidence.

Deposits of Gaytonthorpe.

The valley of the Nar opens to the estuary of the Wash. Its marine clay, described by Mr. Rose*, containing shells exclusively of existing species, associated with bones of extinct elephantine mammals, follows the windings of the valley for three miles to the north-east, and for about the same distance to the south-east. Its range, laid down by Mr. Rose on the Ordnance sheets exhibited to the Society, shows that the width of this ancient estuary formation is, on the average, about half a mile. Two miles north of its eastern half, and at a somewhat greater elevation, is the smaller valley of Gaytonthorpe, opening also to the Wash, and ranging north-east for about two miles from the village of Gaytonthorpe. It is filled with deposits, the variable character of which is shown in the several marl and clay pits opened along its course. Their width, which is somewhat more than a quarter of a mile at the western end, contracts to less than one-eighth of a mile at the eastern end. They are traversed nearly in their centre by the road from Gaytonthorpe to Massingham Heath.

The following is a description of the sections exhibited at the different pits, commencing at the most western.

* *Loc. cit.*

North of the road, in a brickfield laid down on the map above referred to, is a bed of blue clay opened to the depth of about 12 feet which resembles that of the Nar, with the difference that it contains some small pebbles of chalk, and that no organic remains have been found in it.

About half a mile east of this, still on the north side of the road, is a pit now full of water, but reported to have exhibited, when worked, the same characters as the last.

Three furlongs further eastward on the southern side of the road is the pit of freshwater clay and calcareous sand which I have described in the paper on the Geology of Norfolk*, previously referred to, and from which I extract the following section (fig. 1, p. 28) and description:—

"In this pit several beds of clay and calcareous sand rest upon the irregular surface of a bed resembling the chalky varieties of the till. The surface consists of a loamy warp, containing in some parts accumulations of flints of considerable size, and filling furrows and pipes deeply excavated in the calcareous sand and associated clay. The depth and extent of the several beds will be best understood from the accompanying section. From the spot where the word 'Bones' occurs, Mr. Rose has obtained a nearly complete set of the teeth of the lower jaw of a species of *Bos*. From the numerous fragments of a very thin univalve in the calcareous sand, accompanied by horny opercula resembling those of a small *Paludina*, and from part of a *Unio* occurring in one of the beds of clay, I was satisfied that they were freshwater deposits. The specimens which I procured were too imperfect to enable me to obtain an opinion from an eminent naturalist, but Mr. Rose, who conducted me to the spot, and who was reluctant at first to believe them fluviatile, has recently set the question at rest by the discovery of several specimens of *Cyclas* and one of *Planorbis*." This pit not having been worked since 1846, I can add no further particulars respecting it; but several other pits have been opened higher up the valley, which I have recently examined, and which I shall now describe.

About three furlongs east of the last, in a plantation marked on the map, at the point where the road from Gaytonthorpe to Massingham falls into that from Lynn to Litcham, is a gravel-pit worked to the depth of between four and five feet, consisting of coarse chalk flints, very few of them at all abraded. About six chains further east is a clay or marl pit, of which the following is a section:—

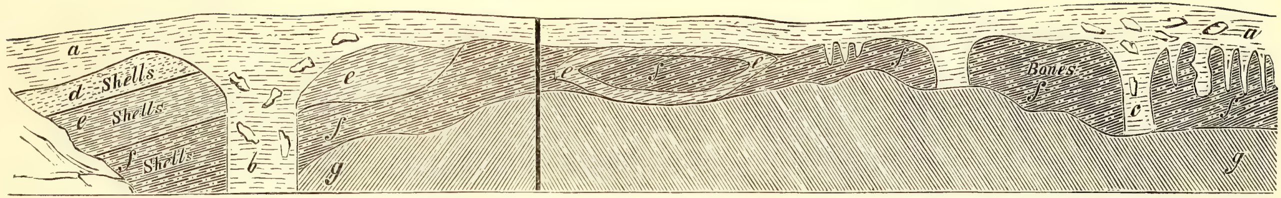
1. At the surface sandy loam, varying in depth with the depth of the furrows and pipes in the subjacent marl from 1 to 4 feet. It contains many coarse flints like those of the gravel-pit, but not quite so large; the greater portion quite sharp, a few however slightly waterworn.

2. A cream-coloured marl, coarsely laminated, with oblique lines of stratification transverse to the direction of the valley, some alternating seams of sand, and seams of chalk pebbles. On the north side of the pit the cream-coloured marl alternates with dark clay, the mate-

* Journn. Roy. Agric. Soc. vol. vii. part ii.

Fig. 1. *Section at Gaytonthorpe.*

East. Vertical and horizontal scale, 20 feet to 1 inch. South.



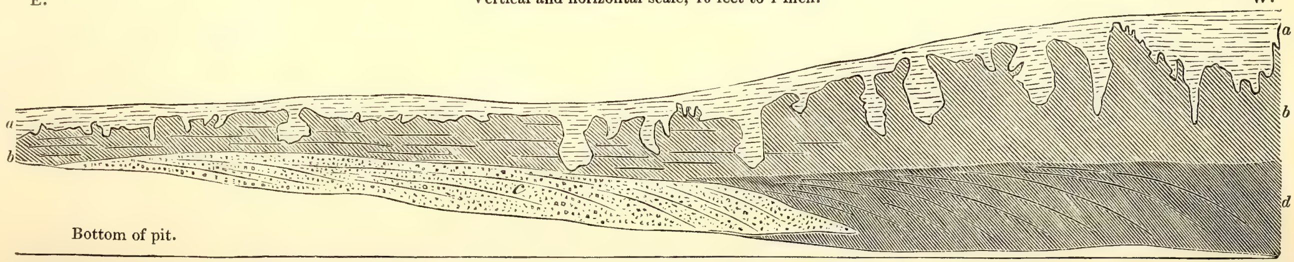
a, *a*. Warp of the drift, sandy loam, containing unabraded flints, some of them of large size, as at *b* and *c*.

d. White calcareous sand.
e, *e*, *e*, *e*. Grey and yellow silt.
f, *f*, *f*. Grey clay.
} Freshwater beds.

g, *g*. Drift, resembling the most chalky varieties of the Till; and containing fragments of chalk with flints, and fragments of Kimmeridge clay and other oolitic rocks.

Fig. 2. *Section at Gaytonthorpe.*

E. Vertical and horizontal scale, 10 feet to 1 inch. W.



a. Warp or surface-soil, composed of fine, ferruginous sand, derived apparently from the greensand series, with angular flints dispersed through it, and filling pipes and furrows in the subjacent marl.

b. Marl more calcareous than *d*, slightly laminated, laminæ horizontal. It passes in the space of about 20 yards into a nearly unlaminated mass.

c. Gravel composed of small flints, both rounded and angular; false-bedded; resting, apparently, on clay like *d*, but the base of the section obscured by debris and by the floor of the pit having been cut up by cart-wheels.

d. Laminated, grey and yellow clay; laminations oblique, and from $\frac{1}{8}$ to $\frac{1}{2}$ inch thick; with occasional seams of ferruginous sand and false bedding. No fossils discovered.

rials derived, apparently, from the Kimmeridge clay: depth opened about 12 feet. No fossils discovered in any part of the series.

The following is the section at a pit about three furlongs east of the last, on the south side of the road:—

1. Sandy warp, filling pipes and cavities in No. 2, and varying in depth from 1 to 4 feet.

2. Sand and clayey sand, obscurely laminated, the lines of stratification being transverse to the direction of the valley, with seams of chalk pebbles, and fine chalk detritus; the upper four or five feet more calcareous and marly than the rest: total depth 15 feet.

3. More clayey and with less appearance of lamination than No. 2. Pebbles of chalk dispersed throughout: depth 12 feet; based apparently on sand. No fossils discovered in any of these beds.

After passing an old pit on the north side of the road, in which the nature of the deposits cannot be made out, another occurs also on the north side of the road, a section of which, from east to west, or in the direction of the valleys, is shown in fig. 2.

In about five chains more these deposits cease, and chalk comes to the surface, having only a covering of a sandy warp with dispersed flints. This is the general covering of the higher grounds to the east, resting either on the chalk, or on patches of chalky till with oolitic fragments, and filling cavities in the subsoil on which it rests. On Massingham Heath are some accumulations of gravel which I have not yet examined; similar accumulations of gravel in the upper part of the Nar valley, by the road from Castleacre to Swaffham, appear reconstructed portions of the upper erratics.

The extent of the Nar clay is only laid down on the Ordnance sheets exhibited before the Society as far as Mr. Rose has traced it in actual sections, but he has reason to believe that it extends somewhat further east, or nearly to Westacre.

Postscript on the CONTORTED STRATA *of* CROMER CLIFFS.

The phænomena to be explained in the case of these contortions (see above, p. 22) are the following:—

1. Horizontal strata, both of chalk and crag, below the till (Lyell, Phil. Mag. vol. xvi. p. 363; and Proc. Geol. Soc. vol. iii. p. 173).

2. The till, obscurely stratified, and passing upwards into laminated blue clay, which again graduates into the yellow silt and sand of the upper erratics.

3. An irregular surface of this till, noticed by Sir Charles Lyell in the following words:—"At some points where the stratified clay reposes on the till, the surface of the latter is very uneven, and was evidently in that condition when the superior deposit was thrown down upon it." (Proc. Geol. Soc. vol. iii. p. 176.)

4. The contortions are confined to the hollows between the projecting points of till, and are the greatest where the surface of the till is most irregular. I had asserted this (Proc. Geol. Soc. vol. iv. p. 436; and Quart. Journ. Geol. Soc. vol. i. p. 219) before the ice theory had occurred to me, as an indication that the till had exercised

some influence in producing the contortions. Above these contortions, beds of sand and gravel, without any apparent stratification, are often succeeded by others in which it is distinctly horizontal.

The conditions which appear to explain these phænomena best are:—

1. The imbedding of masses of floe-ice (not icebergs), varying from 6 to 50 feet in thickness, in the till, and their being fixed beneath the water, as similar masses were found fixed in the viscous mud by Sir E. Parry, who speculates on them, at the suggestion of Captain Sabine, as the cause of underground ice in cold countries.

2. An irregular surface of till caused by the imbedding of these masses of ice, the upper surfaces of which were probably also irregular.

3. The covering, as the coast subsided, of the ice, thus fixed under water, with thin alternations of laminated clay and sand, followed by massive sand and gravel.

4. The melting of the ice, on the return of a milder climate, beneath a superincumbent mass of sand and gravel more than 300 feet thick.

5. The vertical pressure of this mass resolved into a lateral force in the vicinity of the parts lately occupied by the ice (now cavities, or weak places filled with the subsiding strata), so as to squeeze together the walls bounding these spaces in the till previously occupied by the ice-blocks. This lateral pressure would be analogous to the *creep* in coal-mines, where, on the removal of the pillars, it is not that the roof sinks, from the pressure of the superincumbent mass, but the floor rises.

These views may be perhaps better elucidated by diagrams of the different stages of the process by which the contortions were brought about.

Figs. 3, 4, & 5.—*Ideal Sections, illustrative of the conditions which may have given rise to the Contortions of the Strata in Cromer Cliffs.*

Fig. 3.

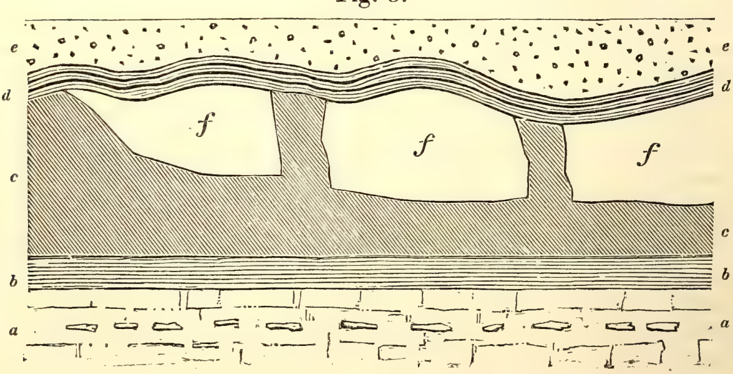


Fig. 4.

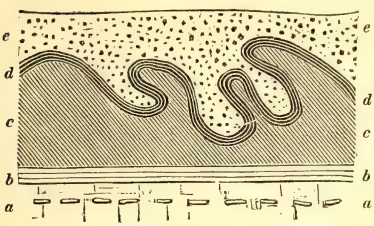
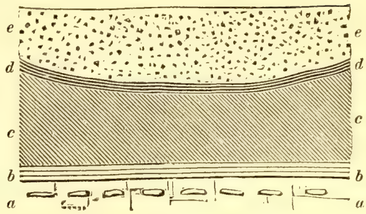


Fig. 5.



a, a, a. Chalk.
b, b, b. Horizontal sand and clay.
c, c, c. Till.
d, d, d. Laminated sand and clay.
e, e, e. Massive sand and gravel.
f, f, f. Ice-blocks.

In fig. 3, the laminated clays and sands (*b*), reposing on the chalk-rock (*a*), are covered by till (*c*), in which fragments of a thick sheet of ice, broken in the act of being fixed—blocks of floe-ice (*f, f, f*)—are imbedded. On the irregular surface of the latter, laminated clays and sands (*d*) have been conformably deposited, and followed by massive sand and gravel (*e*). Fig. 4 represents the complicated contortions which may be supposed to have resulted from the subsidence of the superincumbent beds into cavities formed by the melting of such ice-blocks as are shown in fig. 3 (*f, f, f*), the spaces between the blocks being occupied with peaks of till. Lastly, fig. 5 will represent a case of gently curved strata above the till, very common in these cliffs, where the area of the imbedded ice may be supposed to have been great and its thickness small.

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3. *On the* Origin *of the* Soils *which cover the* Chalk *of* Kent. By Joshua Trimmer, Esq., F.G.S.

The origin of soils and their distribution are questions of considerable theoretical interest; because they involve the history of a terrestrial surface during the period which intervened between the desiccation of the bed of the glacial sea and the commencement of the historic æra of Geology.

Although, from the proximity of this period to our own times, it is that respecting which we might be supposed to possess the most information, it is nevertheless that which is involved in the greatest obscurity, because it has been studied the least. It has either been neglected as unworthy of notice, or at any rate less attractive than the study of the older fossiliferous series; or it has been shunned as beset with insuperable difficulties; whilst in some instances impatient attempts have been made to solve its problems zoologically from insufficient data and from an assumed sequence of organic remains.

The origin of soils and their distribution are likewise questions of great practical importance in the application of Geology to Agriculture; because they involve the question whether the composition of soils is identical with that of the beds on which they rest; and if not identical, then under what circumstances and within what limits they are different. The received opinion is, that the majority of soils have been formed *in situ* by the atmospheric erosion of the subjacent strata; and that the colours of Geological Maps as at present constructed may be received as exponents of the variations of soil.

The study of the superficial deposits for more than twenty years, several of which have been devoted to the mapping of the surface-variations, has convinced me that this opinion is erroneous, and that the majority of soils and subsoils in the British Isles are composed only in part of the debris of the rocks on which they rest, and in part of materials transported from various distances by forces of considerable intensity, differing from ordinary atmospheric action, which were in operation at the close of the glacial period. I have called their results the Warp of the Drift, or the Erratic Warp. The name is, perhaps, not the best that might have been selected; but, having adopted it in the first paper which I published on this subject, I adhere to it until geologists shall substitute a better, or shall disprove the existence of the deposit to which I apply the name. The erratic warp answers to the "active soil" of agriculturists, which comprehends more than that portion of the soil actually cultivated. The terminology of Agriculture is, however, too indefinite even for its own purposes; and it is not desirable to transfer it to Geology.

During the examination of the superficial deposits, the results of which are given in the communication immediately preceding this, and in certain published and unpublished memoirs therein referred to, phænomena were observed (p. 25) which afford at least strong presumptive evidence that the accumulation of many of those fluviatile and lacustrine deposits which contain bones of large pachyderms, now either wholly or locally extinct, associated with molluscs of nearly the same species as those now inhabiting the neighbourhood, took place after the emergence of Britain from beneath the glacial sea, and prior to those aquatic operations, whatever they were, which produced the erratic warp or surface-soil. If these views are correct, it follows, that since the same mammals inhabited this country before the glacial submergence and after it, and since the molluscs were in both cases nearly the same, organic remains will afford little aid in distinguishing deposits formed during different portions of one zoological epoch. In these investigations, therefore, we must rely chiefly on physical evidence,—on superposition when it can be found, and on the relation of insulated deposits to other deposits whose date can be ascertained by their superposition to strata of known age.

If, for instance, we find that the beds of the Norwich Crag had been converted into a terrestrial surface, inhabited conjointly by *Rhinoceros tichorhinus*, Cuv. and *R. leptorhinus**, Cuv., and that the freshwater deposits containing their remains are covered by the marine deposits

* "Mr. Fitch of Norwich possesses specimens of upper and lower molar teeth of the *Rhinoceros leptorhinus* from the freshwater (lignite) beds on the Norfolk coast, near Cromer, which demonstrate the occurrence of this species in the same deposit with *R. tichorhinus*." (Owen's Brit. Fossil Mammals, p. 381.)

of the boulder clay, or lower erratic tertiaries, and these again by the sand and gravel of the upper erratic tertiaries, and if we find on the denuded surface of these erratic tertiaries freshwater beds containing the remains of extinct mammals,—their surface furrowed, and the furrows filled by another unconformable deposit which extends to various heights, and fills similar furrows in the denuded surface of the erratic tertiaries and older strata,—there can be no doubt that the operations which produced these phænomena at higher levels than the freshwater beds, and on the denuded surface of older strata, were subsequent to the interval during which the desiccated bed of the glacial sea was a terrestrial surface, inhabited by the large pachyderms. Again, if tracing the deposits of the glacial sea southwards, from Norfolk to the northern edge of the valley of the Thames, we there find gravel resting on the boulder clay, we may safely identify that gravel with the upper erratics of Norfolk, even although it may occur in disconnected patches, the result of denudation—a form in which it is also frequently found in Norfolk, and notwithstanding some difference of lithological character; and if, on the south of the valley of the Thames, we find similar gravel to that of its northern edge at levels which prove them to be disconnected portions of a stratum once continuous, we may safely identify the gravel south of the Thames with the upper erratics of Norfolk, even although the lower erratics be absent, and although the gravel be in immediate contact with the eocene tertiaries or the chalk. At any rate the onus of proof lies with those who assign to it a higher antiquity.

Again, if at lower levels, within the valley of the Thames, at short distances from the present stream, and at certain heights above it, bones of extinct pachyderms and fluviatile shells,—the shells with one exception identical with those now inhabiting the neighbourhood, —are buried beneath gravel composed of the same materials as that at the higher levels, it is a legitimate inference that the gravel in the trough of the Thames has been derived from that of the higher levels, brought down by denuding processes; and that the mammalian deposit is more recent than the upper erratic tertiaries, and consequently than the Norwich Crag*.

This inference is indeed confirmed by granitic detritus being found associated with the mammalian remains, since debris of this rock does not occur in the Crag, or in any tertiary strata older than the glacial submergence.

Against such evidence we should be wrong in inferring that the mammalian deposits of Clacton and Brentford were of different ages, because the one contains only *Rhinoceros leptorhinus* and the other only *R. tichorhinus*, which were co-inhabitants of Britain before the glacial submergence; and because, at Clacton, in addition to the living species of molluscs of the neighbourhood, common to the two deposits,

* Substituting denudation during the process of elevation for the "retiring diluvian waters," this is a repetition of the argument by which Dr. Buckland (Geol. Trans. 1st Series, vol. v. p. 521) maintained that the excavation of the valley of the Thames had taken place after the transport of the Warwickshire gravel containing pebbles of the Lickey quartz rock.

a single species is found not now known in a living state, nearer than Egypt. There is nothing more remarkable in a *Cyrena* of the Nile being associated with the molluscs of the present Thames at Clacton, than there is in the association at Brentford of the same shells with the hippopotamus and the rein-deer.

If, again, over these fluviatile deposits of the valley of the Thames, we find beds of gravel and loam destitute of organic remains, and extending beyond the limits of the fluviatile deposits to the high grounds, their thickness varying with the elevation and form of surface, we have a counterpart to the erratic warp of Norfolk, traceable over the higher and lower grounds, deepening in the latter, and covering, at Gaytonthorpe, freshwater and mammalian deposits which fill hollows in the denuded surface of the erratic tertiaries (see figs. 1 & 2, p. 28).

Such I believe to be the facts of the case; but they can only be considered as partially established, until the superficial deposits of the valley of the Thames from its source to its mouth shall have been mapped, and their relations to the deposits of the glacial sea in Norfolk, Suffolk, and Essex shall have been satisfactorily determined. I know of no other mode of solving the question, than by laying down the variations in the deposits of that sea, with the same attention which has been bestowed on the older sea beds, which have hitherto been exclusively honoured with a place on geological maps.

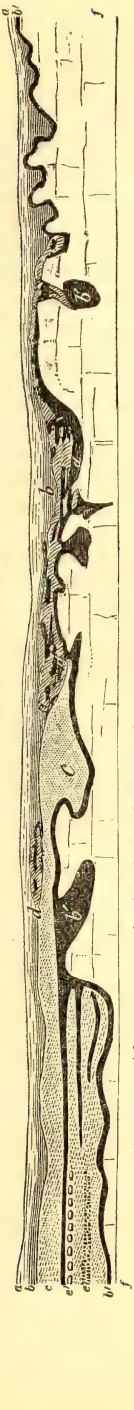
In the present communication I propose to show, that the soils which cover the chalk of Kent at various heights are analogous to the erratic warp of Norfolk; that they are the result of aqueous transport; and not, according to the prevalent assumption, produced by atmospheric erosion which during the lapse of ages dissolved and removed the calcareous matter of the chalk, leaving behind, as upon a filter, its fine siliceous and argillaceous particles and its flints.

The district to which these remarks apply, comprises only a few square miles lying a little to the S. of Dartford; but, if of limited extent, it is a fair type of the Kentish Chalk district in general. The rapid changes of soil in this district, where ferruginous and non-calcareous clay, clay-loam, and loam more or less sandy, as well as white calcareous soils, may be seen in the space of forty or fifty acres, would be a strong presumption against the hypothesis of formation, *in situ*, by chemical solution, unless it can be shown that the composition of the subjacent chalk varies with the variations of soil; and unless a satisfactory explanation can be offered of the solution of the calcareous matter in one case, and its non-solution in another. I shall furnish, however, positive evidence of aqueous transport, in alternation of deposit.

The village of Hartley stands on an elevated table-land of chalk, covered, to depths varying between one and four feet, by a soil of non-calcareous clay-loam passing into a sandy loam, and changing from one to the other within very short distances. The surface is thickly strewn with large unabraded flints and some rounded flint pebbles, referable to the eocene tertiaries, of which there are some outliers a little to the northward, as for instance at the village of Darenth. The

Section in the Road by the Parsonage of Hartley, near Dartford, Kent.

Scale 20 feet to 1 inch.



a, a. Clay loam, with numerous unabraded flints and pebbles of the eocene strata, passing downwards into *b*.
b, b. Dark ferruginous clay.
b′, b′, b′, b′. Dark ferruginous clay, with flints and eocene pebbles, in contact with the chalk.
c, c, c. Yellow sandy loam.
d, d, d. Reconstructed chalk, with patches of clay.
e. A seam of small eocene pebbles, 6 to 10 inches thick.
e′. A layer of larger pebbles.
f. Chalk.

surface of the chalk, at its junction with the soil, has been worn into pipes and cavities, some of which are four or five feet deep. Some of the road-cuttings show light yellow sandy loam, mixed with angular flints and eocene pebbles, resting immediately on the chalk. A little north of Firby Farm, marked on the Ordnance Map, a gradual slope commences to a valley opening into that of the Thames. The road from Darenth to Longfield and Cobham runs through the bottom of the valley. About three furlongs west of Longfield, by the side of the lane leading to Hartley, which ascends the western side of the valley, a cutting at the new Parsonage House of Hartley, now building in a wood marked on the Ordnance Map, has laid open an instructive section of the soil and subsoil above the chalk, the most material portion of which is exhibited in the accompanying section. Where the section approaches the summit and the surface of the chalk rises, the soil consists of loam and clay-loam varying from one and a half to four or five feet with the irregular surface of the chalk. In immediate contact with the chalk is a layer of dark, ferruginous, and tenacious clay, from a few inches to two feet thick, which also fills cavities in the chalk, and passes upwards into clay-loam. In some parts there are collections of reconstructed chalk, containing seams and patches of the same kind of ferruginous clay as that interposed between the surface-soil and the clay which rests upon the chalk; and in one of the pipes are alternations of clay with calcareous matter. Large unabraded flints and rounded flint pebbles of the eocene series are dispersed through all these deposits, and in one part shown in the section, there are accumulations of the small rounded pebbles of the eocene strata.

As the surface of the chalk sinks towards the valley, and the superficial deposits deepen, they become more blended. In the lane between the corner of the wood in which Hartley Parsonage is building and the Church of Longfield, a depth of five or six feet of yellow sandy loam is visible above the chalk; and it constitutes the surface of a field on the western slope of the valley, between the wood and the Longfield and Darenth road. The eastern side of the valley rises more abruptly; and on that side soils consisting of a white surface of chalk, and of brown non-calcareous and whitish calcareous loams, may all be seen within an area of fifty acres. A bed of the last, several feet deep, adjoins the road, a few furlongs north of Longfield. For about a mile northward, between that point and Greenstreet Green, the road passes over a bed of coarse flints, slightly waterworn, though more so than those spread over the surface of the higher grounds. This bed of flints, which is in some parts six or seven feet deep, rests on chalk, and is perhaps about ten chains wide. The eastern side of the valley above it shows some slight indications of terraces, but they are very irregular. I have not traced these deposits northward of Greenstreet Green; but we know that the southern bank of the Thames, in this neighbourhood, is fringed, like the northern, with mammalian and freshwater deposits, at considerable elevations above the existing stream, but lower than the non-fossiliferous deposits described above.

I have myself sent specimens to the Museum of the Society from beds still nearer the mouth of the Thames, in the neighbourhood of Faversham, which extending below the level of high water, exhibit, in their molluscous contents, lacustrine or fluviatile, but not estuary, conditions; and are covered by non-fossiliferous deposits analogous to that of the erratic warp of Norfolk.

In conclusion, I would remark on the similarity of the phænomena of the most recent deposits in a transverse valley extending from the estuary of the Thames to the summit level of the chalk of Kent, to those of the valley of Gaytonthorpe, also a transverse valley, similarly situated with respect to the estuary of the Wash and the chalk which constitutes the highest part of Norfolk; and I would urge on those geologists who attribute the formation of the soil which covers the chalk to solution *in situ* by atmospheric erosion, to examine carefully and impartially phænomena which appear wholly irreconcileable with such an origin.

I would also urge the necessity of endeavouring to work out the sequence of deposits between the Norwich Crag and the historic æra on physical evidence; and, having determined it by those means, to ascertain what organic remains are contained in each member of the series, instead of assigning different epochs to detached deposits, in consequence of the presence or absence of a particular species of mammal or mollusc, which, having existed through the whole period, may be present in certain deposits, or absent from them, solely from local accidents. I would also ask, whether any better method can be devised of working out these questions on physical evidence, than by tracing the phænomena of the superficial deposits from the summit level of a given district through the minor dry valleys into the larger river valleys, in which we find the most recent deposits containing the remains of the great extinct mammals; and by combining and exhibiting those phænomena on maps. Maps of the surface-geology will also be of great importance to agriculture. Professor Johnston was the first to point out the necessity for them. "We have," he says, in his Lectures, "geological maps of all our counties, in which the boundaries of the several rocky formations are more or less accurately pointed out; and from these maps, as we have seen, much valuable agricultural information may fairly be derived. We have also agricultural maps compiled with less care and often with little geological knowledge: but agriculture now requires geological maps of her own, which shall exhibit, not only the limits of the rocky formations, but also the nature and relative extent of the superficial deposits (drifts) on which the soils so often rest, and from which they are not unfrequently formed. These would afford a sure basis on which to rest our opinions in regard to the agricultural capabilities of the several parts of a country, in which, though the rocks are the same, the soils may be different. To the study of these drifted materials, in connexion with the action of ancient glaciers, the attention of geologists is at present much directed, and from their labours agriculture will not fail to reap her share of practical benefit. The Geological Survey, so ably superintended by Sir H. de la Beche, is collecting and recording much valuable information in regard to the agriculture of the Southern counties; but it is not unworthy the consideration of our leading Agricultural Associations, whether some portion of their encouragement might not be beneficially directed to the preparation of agricultural maps, which should represent by different colours the agricultural capabilities of the different parts of each county, based upon the knowledge of the soils and subsoils of each parish or township, and of the rocks, whether near or remote, from which they have been derived."

It was by this hint that I was induced to enter on the task of mapping the surface-geology of Norfolk, having been long satisfied, from previous acquaintance with the superficial deposits, that their influence on agricultural geology was greatly underrated. In the progress of the work I soon discovered, that the variations of soils are mainly dependent on contours;—views which have received confirmation from a fact which has only recently come to my knowledge, namely that this is a rediscovery. It had been asserted as a local truth by an agricultural writer of considerable note*, before the rise of geology and the construction of agricultural maps, and consequently before the over-generalization which pushed the dependence of soils on the strata exhibited in those maps, like the identification of strata by organic remains, beyond its due limits. This map of the surface-geology of Norfolk was, I believe, the first attempt to construct an agricultural map on so large a scale as that of the Ordnance Map, and with so much attention to details. The second was that of part of Cardiganshire which I constructed for the Government Geological Survey. But the first published illustration of the plan, is, as I have recently been informed, that which Professor Johnston himself has appended

* Arthur Young.

to a Report on the Agricultural capability of New Brunswick, which he drew up during his recent stay in America, and which was brought out under the auspices of the local legislature. Not having yet seen that map, I am not aware to what extent, in the execution of the same plan, we have independently followed the same details; from the circumstances under which it was constructed, I presume it can give only a general outline of the distribution of soils in so large a district. That maps of the surface-geology of these Islands would be of great utility, must be obvious to every one who combines agricultural with geological knowledge, and who is aware of the extent to which our country is covered by the superficial deposits, whether we call them drifts, erratic tertiaries, or by any other name. Whatever may be the present fate of such maps, it may be safely predicted, that another generation will not pass away without seeing the construction of them firmly established as a recognised part of agricultural practice, and sedulously cultivated as an important branch of geological research.

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4. *On the* LIMESTONE QUARRY *of* LINKSFIELD, ELGIN, N.B. By Captain R. T. W. L. BRICKENDEN, F.G.S.

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

DECEMBER 4, 1850.

William Bennison, Esq., Thomas Rowlandson, Esq., and Henry William Taylor, Esq., were elected Fellows.

The following communications were read :—

1. *On the* GEOLOGY *of the* UPPER PUNJAUB *and* PESHAUR. By Major VICARY.

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

Introductory Remarks by Sir R. I. Murchison.—In communicating the enclosed letter from Major Vicary to myself, I beg to observe that he obtained his knowledge in an arduous campaign, which led the British forces into regions ordinarily inaccessible to geologists.

Independently of the description of an extensive range of those younger tertiary deposits in the Sewalik hills, with the contents of which we have been made acquainted through the letters of our associates Falconer and Cautley, Major Vicary now calls our attention to palæozoic fossils derived from the mountains which separate British India from Cabul. It appears that Dr. Falconer had previously obtained possession of fossils establishing this point, and I would now state that when I last visited Edinburgh, the Rev. Dr. Fleming showed me *Producti* and *Spiriferi* collected by his son Dr. A. Fleming, of the Company's Service, in the vicinity of the salt range at Musakhail on the east bank of the Indus, which seemed to be identical with carboniferous forms well known in the British Isles. Being unaware at that time of any similar discovery, I urged my friend, the Rev. Dr. Fleming, to make his son's researches known to the scientific world, and to compare exactly the species collected in Western India with those of Scotland, with which he is so conversant.

Having since shown these fossils to M. de Verneuil, he has identified five out of eight or nine species with forms well known in rocks of this age in other parts of the world, viz.—

Productus Cora, *D'Orb.*
—— costatus, *Sow.*
—— Flemingii, *Sow.* = P. lobatus, *Sow.*
Orthis crenistria, *Phill.*
Terebratula Royssii, *L'Eveille*, and several other species of this genus.

Now these fossils have already been known to have an enormous geographical range; the *Productus Cora* occurring in Peru, Spitzbergen, Northern Europe, and the Sierra Morena of Spain; whilst two or three of the other species have an almost equally extensive distribution.

The observations of Major Vicary are thus augmented in value by the discoveries of Dr. A. Fleming; for they prove that the palæozoic rocks have a considerable range in the region of the Indus, a fact hitherto unknown to European geologists.

Kawree Pass leads through a range of low hills rising in some places to about 800 or 1000 feet above the plain, and stretching in a north-easterly direction from Moong and Russoolpoor (near Julalpoor) towards Bhimber. The surface of these hills is barren and devoid of herbage, bearing only small and scattered trees. The formation is composed for the most part of yellow marly clays, with beds of a pale soft sandstone, the whole often capped with conglomerate. The boulders and gravel, disengaged from the latter, fill the water-courses, and are thence carried during floods some distance into the plain below. They are also scattered everywhere over the surface of the hills. I also noticed some thin beds of kunkur (travertine), but found no fossils during my hasty march through the Pass. I think that these clays, with kunkur, conglomerate, &c., will be found to belong to a tertiary formation noticed below.

The range of hills distinguished by Mount Tilla (a high and conspicuous landmark) is north of this range about 30 miles, running nearly parallel to it, with the Jhilum river passing along the intervening valley. The broken and hilly country, however, stretching from Mount Tilla, reaches nearly to the bank of the river, at a point a short distance north-east of Julalpoor. The range of hills entered by the Rotas Pass is a prolongation of that from which Mount Tilla rises, and the mouth of the Pass is probably not more than twenty-five miles east of it; the road, *viâ* Rotas, as far as the Bukkur-Alla Pass (or nearly to it), about forty miles, leads along the bed of the Kuhan river, the sands of which are washed for gold-dust. The outer and lower hills at once reminded me of those I had seen in Scinde, at

Avah, and other places; the same barrenness and yellowish rusty colour of surface, with the broken-up conglomerate scattered everywhere; and here too I found some of the boulders composed of nummulitic limestone.

The sections exhibited by the river show thick beds of yellow marly clay, sandstone (calcareous), and conglomerate. The beds for the first half-mile from the entrance to the Pass are nearly vertical; farther on they acquire a southerly dip, and at last become nearly horizontal; while farther on, near Rotas Fort, the dip is from 45° to 50° west. Near the Fort the clay beds become more developed, the upper beds being often conglomerate with a calcareous cement, from 3 to 10 feet in thickness; some of the boulders here are of nummulitic limestone. Beneath this, the clay beds and thin beds of sandstone alternate. Nodules of kunkur (travertine) are found in the clay. I found some broken pieces of fossil bone on the top of one of the hills near the Fort.

The same low hills and a similar formation are met with about a mile north-west of Bukkur-Alla village with a varying dip; at Udderana, about the thirteenth mile, it is nearly horizontal, and again at the village of Bukkur-Alla, dipping 35° to 45° west. The formation at this place assumes all the characters common to the Sewalik mountains at the base of the Himalayas, near Nahu. The upper bed usually is a calcareous sandstone 3 to 6 feet in thickness, partially covered by the remains of a calc-cemented conglomerate. Fossil bones are found in considerable abundance both in the sandstone and conglomerate, but I believe chiefly from the latter; they are found either in the water-courses, or even on the tops of the hills, detached by the action of the elements, or *in situ*. Beneath the sandstone there is a bed of marly clay with kunkur (travertine) nodules; in the lower part of the sandstone, and also in the upper part of the clay bed, I found numerous *Helices* (*Vitrinæ*?) and *Pupæ*, their interiors being filled with calc-spar. The bones I recognized belonged to the elephant or mastodon (too heavy to carry away), some large Ruminants, Saurians, and Chelonians.

Passing on in the direction of Tumiak, and at about one mile from Bukkur-Alla, the stratification becomes much confused; the sections exhibit deep-bedded, marly, yellow clays and conglomerate, possibly pliocene.

Hence to Bukkur-Alla Pass about five miles; the clays here have been denuded, and the beds which come to the surface are composed of red shale and clay, usually thick-bedded, sandstone and conglomerate, with a dip of from 60° to 90° to the north-east. The beds of red shale and clay being of a soft and incoherent nature, are easily acted upon by the weather, and, owing to degradation, have left the sandstone beds standing out like walls, with the upper margins indented in a grotesque, and often castellated manner. These beds are often of little thickness, and are occasionally surmounted by beds of conglomerate. This formation I believe to be eocene; it is found under various circumstances as far as Jianee-Sung, near the base of the Murgullee range of mountains, but always with considerable dip;

the edges of the beds occasionally showing themselves at the surface all the way.

The Bukkur-Alla Pass is about a mile from Tumiak, and the ascent may be about 500 feet. From this, towards the Murgullee range, a plain, apparently with a somewhat level outline in a general sense, but really an undulating and often broken country, intervenes; the whole distance being probably about sixty miles.

Tumiak is situated on a pliocene formation, which, with many intervals, is traceable into Peshaur and even into the Khyber Pass, and I think it probable that the low range of hills stretching along the left bank of the Jhilum, from near Julalpoor towards Bhimber, belongs to the same formation. Near Tumiak, on the left bank of the Suhan River, a good section of this formation is exposed, showing a depth of about 400 feet. It here consists of deep beds of yellow, marly clay, with travertine nodules, and exhibiting near the base of the whole some unconnected beds of a pale soft sandstone. The clay beds are separated by thin beds of boulders, in some places cemented into conglomerate; the lowest of these beds is about 10 feet thick, and composed of large boulders. In several places the rain-water has found its way through the clay beds down to this bed, and, from its sapping action on the clay, has formed many somewhat circular deep funnel-shaped pits, some of considerable size, but particularly so near the escarpment. The whole of this formation is nearly horizontal, and, whether in Peshaur or at other intervening places, is in a rapid state of degradation. In a few years, geologically speaking, it will disappear. During every fall of rain, large quantities of debris are carried into the water-courses and rivers, the finer portion of which, I have no doubt, contributes to the elevation of the country near Mooltaun and the banks of the Indus.

Hence to Pukkaderaee 14·3 miles. The pliocene is here cut into deep ravines, showing perpendicular sections, particularly at the Seraee.

Twelve miles and a half farther on to Munikyala, chiefly over the pliocene clays, but the edges of underlying red shales and sandstones occasionally come to the surface. The country round Munikyala is undulating: on looking over the surface, it appears like an extensive plain, but it is much broken and cut up into ravines.

Hence to Hoormuk, on the left bank of the Sewan river, ten miles, partly over the same pliocene; near an old Seraee, and about the sixth mile, the conglomerate beds, sandstone, and red shale are pushed above the general level, the sandstone and conglomerate forming walls more than 100 feet in height, with a strike north-east and south-west, the dip from 85° to 90° south. The red shales and clays form the thickest beds; and here too, from the action of the elements, they have been degraded into troughs, and even ravines, leaving the harder sandstone and conglomerate to form either walls above the general level, or sharp precipitous escarpments to the ravines. However, in this neighbourhood, and indeed to the Bukkur-Alla Pass, the upturned edges of these beds have a tolerably equal elevation. Looking over the plain east and west, the country appears ridged with slightly elevated lines and intervening hollows. These hollows are many of them still filled with the pliocene clays to a level with the upturned edges of the sandstone, &c. The pliocene is deep-bedded on both banks of the Sewan river; the conglomerate on the right bank, deep-bedded and held together by a calcareous cement, caps the yellow marl, and is nearly horizontal.

Crossing the Sewan to Rawul-Pindee, about ten miles: at about the third mile, and in the deeply-excavated bed of a branch (or tributary) of the Sewan, I again found the upturned edges of the red shale, clay, sandstone, and conglomerate, which are here nearly vertical; the dip slight and southerly; the strike east by north and west by south.

In a thin bed of conglomerate, with red shale above and below it, I found part of a large tusk, which belonged either to a mastodon or elephant; this broken specimen, *in situ*, was about 2 feet in length, 4 or 5 inches in diameter, and strongly curved. I shattered it to pieces in an attempt to dislodge it. The cement of the conglomerate is very hard and tinged with the red colour of the shale, as was also the fossil.

I noticed here that thin beds of conglomerate and sandstone often alternated. The higher land forming the banks of the river at this place are capped with conglomerate resting on yellow marls, the whole resting on the edges of the red shale, &c.

I found *Pupæ* and *Helices* in the clay. Farther on, in the direction of Rawul-Pindee, there are sections of thin clay 200 feet in height. From these I collected numerous *Melaniæ*, *Helix* (or *Vitrina*), *Pupæ*, and other terrestrial or lacustrine shells.

In the bed of a small water-course, about a mile south-east of Rawul-Pindee, I again came upon the red shales and conglomerate, with the strike and dip noted above. The conglomerate and sandstone here have an intensely hard cement, and the pebbles in the former are small. Firmly imbedded in the weathered surface of these beds I detected numerous fossil bones; I was hurried at the time (on the line of march), and could only disengage a few broken fragments.

From Rawul-Pindee to Jianee-Sung, thirteen miles and a half: over the pliocene for the greater portion of distance: in many places I remarked large masses, or rather irregular rocks of travertine, partly or altogether disengaged from the yellow pliocene clays; and in some sections near Jianee-Sung I observed this travertine forming distinct beds in the yellow marl, having its upper portion soft and porous, but becoming hard and solid downwards.

From Jianee-Sung one mile and a half to the Murgullee Pass, and the range of hills through which it leads; the land gradually rises; the surface is everywhere covered with loose rounded boulders, many of which are nummulitic limestone. Sections obtained near the base of the Hill-range exhibited the same conglomerates and thick-bedded yellow marls previously noticed. I was unable to obtain any particular name for this range of mountains; I shall therefore call it the "Murgullee Range," from the name of the Pass. Their direction coincides with the strike, viz. east by north and west by south;

the dip southerly, the angle varying much at the different points examined.

Near the base of the southerly side I noticed some beds of a coarse hard limestone of a reddish tint, containing an abundance of broken shells, all tinged with a bright red colour: higher up the hills, which are limestone, and particularly on the northern face, I noticed some beds abounding in *Nummulites*, but I detected scarcely any other fossils in my hurried visit: a *Pectunculus* and some *Polyparia* were however found.

The part of these hills visited is about a mile east of the Murgullee Pass, and I imagine about 1500 feet above Jianee-Sung. The base of the range here is little more than a mile and a half across, but further to the eastward the base expands, and the mountains attain an elevation of 2000 to 3000 feet above the country beneath. I was informed also that, in the same direction, sulphur-mines have been worked.

The pliocene clays and conglomerates are again found covering the northern base of these mountains and filling the depression between the Murgullee hills and Hussun-Abdal. The latter place is situated at the foot of some hills, attaining an elevation of 1500 feet above the plain. I was unable to examine the hills, but judging from what I saw, they are limestone: round their base and on the banks of the river (a branch of the Aroo river) are scattered numbers of water-worn boulders, many of which are granite, brought here in all probability from the mountains to the eastward. The gravel of the Indus, at Attock, also contains many granitic boulders, which have been brought down the stream from the same direction.

From Hussun-Abdal to Attock, about thirty-five miles, for the most part over the pliocene formation; it is much broken and cut into ravines, some of which widen even into broad valleys, now under cultivation. At other points, where disturbing causes have not affected it, elevated plains of considerable extent remain unbroken and with a pretty level outline. The sections bounding these elevated plains are usually abrupt, but particularly so near Boorin, the height above the denudation being from 200 to 300 feet. These sections often exhibit beds of travertine, which, when sand is in excess, passes into a pale, soft, calcareous sandstone. A fine *Pupa*, now existing plentifully from the Jhilum to the Khyber Pass, is found abundantly in this formation along with others mentioned above.

The Fort of Attock is situated on the northern base of a range of slate mountains, to the age of which I could obtain no clue. The slate beds near the foot of the hills are very dark-coloured; higher up the rock becomes paler and of a blue tint, and is easily split; at one place I noticed men at work splitting it into slabs for headstones for the graves of the Moosulmauns. The pliocene formation is found round the base of these hills, resting horizontally on the edges of the slate. To the eastward the action of the Indus seems to have destroyed it for a considerable distance inland from both banks.

East and north-east from Attock there is an extensive alluvial plain, covered at the time I passed (March) with fine crops of grain.

The river, on reaching Attock, has to force its way through a narrow gorge between the slate mountains which rise on both banks, and it is only necessary to imagine this gorge closed, to form extensive lakes over much of the country where I have noted the existence of pliocene deposits.

Crossing the Indus and *viá* Geedur-gullee Pass to Akhora, about eleven miles;—the Pass nearly half the distance leads through a formation, chiefly slate, occasionally showing thin beds of an altered limestone and veins of quartz. The beds are usually nearly vertical; the dip to the south, with an east and west strike. I saw no fossils; indeed in both going and returning I was obliged to move on quickly.

Disengaged from the Geedur-gullee, at about the fifth mile, and near the village of Nuwazeerun, I again noticed the pliocene formation; the Caubul river has here cut its way through it. On the left bank it appears to be elevated and to form some low hills, rising 300 or 400 feet above the river. I was unable to cross and verify this observation, but obtained sections on the right bank down to the slate rocks. First, in descending order, there is a thick bed of yellow marl with numerous individuals of *Melania, Pupa, Helix,* and *Unio,* all in a state of decay, usually crumbling to pieces on being taken out. Beneath this travertine (kunkur) there is a bed of conglomerate, included in which I found some pieces of pottery. Next came yellow marl with *Septaria*; below this a thick bed of conglomerate with a calcareous cement, beneath which the yellow marls were again repeated. In the lower conglomerate I found the rib of some large animal (Camel?); it was so firmly held by the cement that I could not free it without fracture; the cancellated structure of the bone was not entirely filled up, and its mineral state would at once refer it to the most recent geological period.

From Geedur-gullee the slate hills recede southerly from the Caubul river, forming the southern boundary of the Peshaur valley (or rather basin). As far as the eye could reach I traced the pliocene formation along their base, deeply cut into ravines by water-courses, and perhaps from other causes; but, although so broken, the surface-outline holds nearly the same level throughout, except near the base of the mountains, towards which there is a slight and gradual rise. Near Akhora I noticed many huge masses of an igneous rock scattered along the banks of the river, but could not discover whence they came. Sections nearer to the town of Peshaur showed beds of the gravel and conglomerate thicker, but in other respects similar. Near Jumrood, and along the base of the Khyber mountains, the pliocene clays are replaced by boulder and gravel, derived chiefly from the Khyber range. The pliocene, however, is found even in the mouth of the Khyber Pass, and the cave dwellings of the Khyberees are excavated in it.

Owing to the intractable and savage nature of these people, it was impossible to examine the Hill country*; I was obliged to content

* Dr. Bow of my regiment, eager to aid me, mounted his horse, and rode to the foot of the nearest hills with the intention of bringing away specimens of the rock: he had scarcely got there when he found himself suddenly in the midst of

myself with the most angular and freshly detached boulders obtained from the water-courses leading from the mountains. In some of these (limestone) I detected a small *Spirifer, Orthis* in abundance, a *Terebratula*?, and some *Polyparia*. But I fear some time will elapse before more conclusive information with respect to the geological history of the Khyber mountains can be obtained*.

For these notes which were made on the roadside, during the pursuit of the flying Seiks by the division under General Gilbert, and eventually to the Khyber Pass, in pursuit of Dost Mahommed and his Afghauns, I have to crave some apology. I could only record whatever came under my observation on the line of march, and was unable to devote the time and attention which strict geological investigation demands. I believe, however, that I have been able to bring to notice the existence of a deep-bedded and extensive pliocene formation, extending, with intervals, from the Jhilum river to the Khyber Pass. The formation, holding a westerly dip near Rotas and the village of Bukkur-Alla in which fossil bones were observed, I should approximate to the age of the Sewalik range of hills flanking the base of the Himalayas, and which have been so ably illustrated by the labours of Dr. H. Falconer and Captain Cautley. Dr. A. Fleming, who visited Pind-Dadun-Khan and the salt-mines, appears to have met with the same formation near Baghauwala and Mount Tilla†. I stated above that the Rotas hills were a prolongation from the base of Mount Tilla to the eastward.

The red shales and clays, sandstone and conglomerate beds beneath, to which I have ventured to apply the term Eocene, are, I have reason to think, the same formation so productive of salt near Pind-Dadun-Khan. It is true that, with the exception of fossil bones, I found nothing in these beds to enable me to identify them; but Dr. Fleming's account of the salt-yielding shales‡ leads me to this conclusion. Further, I believe that the red shales near Subathoo belong to the same series; and this observation gathers weight when we remember that salt§ is obtained from the red shales of the Mundee district, on the right bank of the Sutlege, within fourteen miles of Belaspoor and hardly fifty miles N.N.W. of Subathoo. Dr. H. Falconer in a letter to me states that he found these red shales, &c. between Nahu and the Choor mountain, about sixty or seventy miles south-west of this (Subathoo), and also mentions his suspicion that they correspond in age with the red shales and limestones noticed by him in the salt range of the Upper Punjaub.

I continued my exploration of Subathoo and its vicinity during the last cold season, and can now with certainty state that fossil

armed Khyberees; they fired at him, and during his hasty flight, the horse refusing a leap, he was thrown; fortunately, however, he again caught his horse, and escaped without injury.

* Dr. Falconer obtained specimens of *Spirifer, Orthis,* and other palæozoic forms, from these mountains some years ago.

† *Vide* Calc. Journ. As. Soc., No. 205. p. 673.

‡ *loc. cit.*

§ This salt is called Goomba; it is very dark-coloured and impure; much fine gravel is often diffused through its substance, some of the grains of which have an organic appearance (*Foraminifera*?).

bones, but particularly saurian, are to be found over an area of ten miles; I have found them in the red shale, in a bluish pale-coloured shale, and in the limestone beds. The bluish shale passes gradually into the limestone beds, and the fossils are similar; they are, however, very ill preserved in the shale and often recognised with difficulty.

I hope at a future time to be able to give a more minute account of my present locality, Subathoo.

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2. *On the* Silurian Rocks *of* Dumfriesshire *and* Kirkcudbrightshire. By R. Harkness, Esq. *Communicated by J. C. Moore, Esq., Secretary G.S.*

In addition to the detrital, superficial deposits of sand, gravel, and clay, the geological formations of the county of Dumfries consist, in descending order, of a red sandstone, the age of which is not yet determined, of coal-fields and carboniferous limestone, and of Silurian rocks.

The greater part of the county (excepting always many masses of trap rock) is indeed exclusively occupied by rocks which I consider to be of Silurian age, and which cover an area more than twice the size of that possessed by the other formations conjointly. The Silurian formation is exhibited in few natural sections, the country over which it prevails consisting in a great measure of comparatively low undulating hills, covered with soil and debris. The course of the rivers, moreover, which drain the district being in a great measure through valleys filled with the newer deposits, it is chiefly in the smaller brooks that such natural sections can be obtained, as afford an insight into the constituents of the Silurian rocks. These and the cuttings of the railways, combined with a few small quarries, are the principal means by which the rocks are exposed; and consequently it requires a considerable extent of country to be traversed, and a number of brook-courses to be examined, before any idea can be formed on the nature and relation of these deposits.

The term *greywacke*, as it is generally used, well expresses the mineral nature of the rocks which compose the Silurians of Dumfriesshire, whether these rocks assume a schistose or a granular character; but the term *slate* is totally inapplicable, inasmuch as no true slaty cleavage has hitherto been discovered amongst them. Greywacke is not, however, the exclusive composition of the mineral masses; for in some localities soft shale, resembling in every respect the shales of the coal formations, is found. Besides this soft shale, beds of anthracite occur; and so intimate is the connection between the latter and the soft shales, that the one is a constant concomitant of the other.

Anthracite and Graptolite Schists.

First Band.—Commencing near the mountain of Hartfell, one of the highest in the south of Scotland, and near the junction of Dumfriesshire with Peeblesshire, there are seen in a rivulet, running along the south-western base of the hill, shales and anthracite beds. These occur near the chalybeate spring, and are well seen in the course of the brook below this spot. Immediately below the mineral spring the shales cross the brook; and here they consist of thin-bedded layers of a dark grey colour. In following the brook downwards the anthracite appears, and in it a horizontal shaft has been driven. This deposit consists of thin beds, which are very much traversed by rents in different directions, and intersected by numerous thin veins of quartz. The dip both of the anthracite and of the dark shales is indistinct, both being much contorted, the latter also being greatly affected by movements which have produced slickenside surfaces. The strike, however, is well-marked, and has an E.N.E. and W.S.W. direction. Independent of the contortions in these beds, it is probable that they have a N.N.W. inclination at a high angle, that being the prevailing dip of the greywacke in the hills which lie both north and south of this locality. The relative position of the anthracite and the shale to each other appears to be, that the former is an inferior deposit upon which the dark-coloured shales repose. Amongst the anthracite beds portions of *Graptolites* are sometimes met with; but these are not in general well-marked. In the overlying shales similar fossils occur in great abundance and in a fine state of preservation. They are referable to the genera *Graptolites* and *Diplograpsis,* and the species found in this locality are mostly of this latter genus.

In following the direction of the strike of these beds of shale and anthracite to the S.W., we come upon a narrow band of red sandstone in the higher portion of the vale of the Annan; after traversing this, we again meet the greywacke of the Silurians; and at a small burn called Hawkshaw Linn, the dark shales and anthracite beds also present themselves. At this locality, which is about four miles along the strike from that previously mentioned, the same description of strata occurs; the shales have, however, a redder aspect and the inclination is more distinct. Continuing in the same direction we find the shales and anthracite crossing the river Evan at a place called Rittenside; and a mile S.W. of Hawkshaw Linn, at Greskin, in a cutting of the Caledonian railway, we come upon the same beds. In some intercalated beds of compact greywacke which here occur, orbicular bodies are found which seemed to resemble crustacea of the genus *Cythere*; but they prove to be concretions only. The inclination of the strata is here very distinct, being towards the N.N.W. at a high angle; a short distance below, in the course of the river Evan, the dip is only 30° N.N.W. S.S.W. from this locality, at the west base of the Rivox Hill, the shales are again seen; and here their appearance was such as to induce a former tenant to sink a shaft of considerable depth, under the impression that they would yield coal.

About six miles from this spot, in the same direction over the hills, the shale and its concomitants are again exposed about half a mile from the Shepherd's house at Branrigg, in a small brook which runs in a S.E. direction from the base of Little Queensberry to the Ae Water. In the course of this brook the strata are well developed, and are inclined in the usual N.N.W. direction ; they consist of anthracite, grey shale, black shale, and thin bands of soft white shale, almost resembling clay. These beds are traversed with numerous fissures and slickensides, so as to be in a great measure fragmentary. *Graptolites* occur in both the grey and the black shale, but not in the white. They are, however, more abundant in the black shale, and are commonly converted into iron pyrites. This shale has a strong styptic taste, owing to the decomposition of the iron pyrites and the production of sulphate of iron. Above these deposits a series of thin-bedded, light drab-coloured shales prevail, which are also fragmentary, and generally divided into rhomboidal portions by fissures. These beds dip at an angle of 62° N.N.W., and have dark-coloured graptolitic shale interstratified in their higher portions; no fossils, however, are to be seen in the drab-coloured shales.

After crossing the range of hills separating the Ae from the Bran, the anthracite and shales are again met with in the course of a small brook which joins the Bran at a spot called Wee-fall Cleugh.

Second Band.—Returning again to near the point where the graptolite beds were first described, we find, near Birkhill, eastwards from Hartfell at Dobbs Linn, where Dumfriesshire and Selkirkshire join, similar beds, extensively developed, and presenting all the characters that indicate the anthracite and black shales. On a line parallel to that before mentioned, and seven miles S.W. of Dobbs Linn, we meet with a continuation of this bed in the course of the Frenchland Burn, near Moffat ; here *Graptolites* are found in considerable quantities in the dark-coloured shales. The brook runs along the strike of these strata until it approaches the Frenchland Tower, where the red sandstone makes its appearance, under which the anthracite beds extend in a W.S.W. direction. The inclination of these beds is in the usual N.N.W. course at a high angle, and the hill, rising immediately on the north side of this brook, and consisting of greywacke sandstone, has its strata dipping in the same direction at an angle of 70°. In a quarry on the Hunterheck farm, a short distance to the south of Frenchland Burn, the beds are composed of fine-grained greywacke sandstone with intercalated shales, dipping N.N.W. at an angle of 73°. Annelid-like impressions, with vermicular and other indefinite markings, occur on the faces of some of the beds.

After passing under the red sandstone the graptolite beds are again seen at Garpool Linns, about a mile north from Beatock. South of this the inclination becomes confused, and below the junction of the Garpool with the Evan, in the latter stream, the dip is towards the E.S.E. at an angle of 73°; the rock consisting of red and grey greywacke, shale, and greywacke sandstone.

Between this locality and Moffat a trap dike of considerable magnitude occurs, which is well exposed in the quarries of Coates Hill. This may probably have been the cause of the local disturbance in this neighbourhood. My attention was directed to this dike by Sir Roderick Murchison, who, seeing that its course to the S.E. passed by Craig Fell Hill, thought it would probably be found to proceed from the great mass of trap near Langholme.

At Duff Kinnell, not far from Rae Hills, and at several other spots in the neighbourhood, the same anthracite and shales are found. One species of Graptolite (*G. Sedgwickii*) occurs here in great abundance and of large size; other species also are found, but not in such great numbers. The dip in this locality is more to the westward than commonly prevails, being at an angle of 50° W.N.W., and consequently the strike of the beds between this and Beatock has a more north and south direction. In the bed of the river Kinnell the same direction of dip prevails amongst the purple and greywacke sandstones which are there exposed.

In the Glenkiln Burn, in the parish of Kirkmichael, about eight miles north from Dumfries, we also find these graptolitic beds. In the lower portion of the brook, and below where the anthracite occurs, fine-grained greywacke sandstone is met with, dipping N.N.W. at an angle of 55°, the beds varying in thickness, and interstratified with red and purple shales. Higher up the brook, beds of a similar nature are seen, but the inclination is only 30°. Above these the dip again becomes 55°; and here are seen hard shaly anthracite beds, including softer shales, and resting apparently immediately upon the greywacke sandstone. In these deposits *Graptolites* are occasionally seen, including *G. Nicoli*.

In some portions of the anthracitic shales, small nests of a black carbonaceous matter resembling soot are frequent. These strata are much contorted, and traversed by thin veins of white quartz; they also present the slickenside appearance so common to this deposit. Immediately above the anthracite a shivery greywacke is seen, imperfect in its stratification; succeeding this are regular stratified beds similar to those which occur lower down the brook, dipping at an angle of 40° N.N.W.; above these lies a dark, shivery, slickensided shale, not anthracitic, in which *Graptolites* occur in great quantities. Above this shale a bed of greywacke, similar to that which overlies the anthracite, is met with. This is succeeded by regularly bedded strata, similar to those in the lower parts of the brook-course, and having an inclination towards N.N.W. at an angle of 45°. Above these, thin beds of greywacke, with interstratified, soft, purple shales, variegated with a greenish grey colour, are found, dipping N.N.W. at an angle of 37°.

The stratified deposits along the course of this brook afford a good example of the general character of the rocks which make up the Silurians of Dumfriesshire. But the sequence of the deposits cannot here be made out, as several faults intersect the strata and entirely destroy all traces of conformity. For instance, in the lower portion of the burn we have the anthracite without its overlying dark shales; and higher up we find the dark shales without the underlying anthracite. The shivery character of some of the greywacke strata indicates the position of the lines of fault.

To the west of this point the direction of this line of dark shales and anthracite becomes obscured. It is probable, however, that after traversing the moorlands to pass under the red sandstone of the lower portion of the vale of the Nith, it is this same band which reappears in the Stewartry of Kirkcudbright, near Shawhead, in the parish of Kirkpatrick Irongrey; then, following the course of the range of hills which runs through the north-western part of that parish, reappears again at Larghill, in the parish of Urr, at which place also a horizontal shaft has been driven into it in search of coal. From hence it continues westward, and is found exposed in a brook-course near Largnairn, in the parish of Kirkpatrick Durham, and here also coal has been sought for in it. It reappears afterwards at a place called Coal Heugh, near the river Tarff, in the parish of Tongueland, about ten miles E.S.E. from the last-mentioned locality.

Third Band.—Returning again to the borders of Selkirkshire to trace another band, we meet with the anthracite beds and the graptolitic shales about four miles south of Dobbs Linn, near Wind Fell. They occur along the course of a brook called Selcoth Burn, which runs into the Moffat Water from the eastward. About two miles east of the junction of these streams is a spot called Craigmichean Scarrs, and here we have the anthracite developed to a much greater extent than at any other locality. Commencing at the lower part of the burn, greywacke sandstone, intercalated with shales and dipping N.N.W. at an angle of about 73°, continues for about a mile to where a small rivulet enters from the north. Here the character of the deposits changes entirely, and the anthracite and shales, with and without *Graptolites*, occur. The hills formed by the anthracitic strata in this neighbourhood present a wide difference, both in contour and vegetation, from the greywacke hills surrounding them. They are very barren, and are somewhat conical in form, having pointed summits, and their sides are covered with the débris of the broken and decomposed shales, through which are thrust pyramidal and boss-shaped masses of anthracite. Hence the wild and desolate scenery of Craigmichean Scarrs. The springs which issue from the lower parts of the hills are strongly impregnated with hydrous peroxide of iron, and have a yellow colour. The pisiform concretions of iron-pyrites were found here in a fragment of one of the shales, and *Graptolites* are also to be met with, but they are far from common; it might be, however, that the beds containing them in the greatest abundance are covered up by the débris of the shale. The anthracite is here much contorted; it is also harder than usual, and is traversed in all directions by small veins of quartz. We also find the anthracite in the Bell Craig Burn, about four miles E.S.E. from Craigmichean Scarrs. The lower portion of this burn, which joins the river Annan from the north-east, in the parish of Kirkpatrick-Juxta, is occupied by the red sandstone; but about half a mile above the Bell Craig Linns the anthracite, with its accompanying shales, is seen. The course of the brook cuts these beds obliquely, and affords good sections of the strata. The lower parts consist of the contorted anthracite, which is overlaid by more regularly bedded shales, abounding in *Graptolites*, and having intercalations of compact, bluish-grey greywacke, of an almost semi-metallic aspect. In this bed obscure traces of organisms occur. Besides the small concretionary bodies like *Cythere* (as at Greskin and Craigmichean Scarrs), there are also sinuous markings, and, in considerable abundance, long, thin, flexuous, tapering bodies. The *Graptolites* here are well-marked and abundant; the individuals of some of the species are of a large size, one being traced through several fragments of shale for more than 18 inches without showing either of its extremities. They do not, however, occur in the bed which affords the concretions and markings, but are confined to the earthy shales. The dip of the deposits here is the same as that which commonly prevails, viz. towards the N.N.W. at a high angle. Of this line of anthracite and graptolitic shale we have no further traces after it passes under the red sandstone at Bell Craig Linn.

General Remarks on the Anthracite and Graptolite Beds.

From the foregoing description of the position of these anthracite beds and graptolite shales, and the direction which they take, it will be seen that three distinct and well-marked courses occur in the county of Dumfries. These bands are in a great measure parallel to each other, the average distance between the bands being about two and a half miles, and although they cannot be traced to the same extent, it is probable that their relation to each other is such, that they were originally portions of the same deposit.

Of the most northerly band, from the point where it makes its appearance in Dumfriesshire to the locality where it is lost sight of, the distance is about twelve miles in a direct line. The second traverses an extent of about twenty miles between Dobbs Linn and the Glenkiln Burn. If, as I think, it be the same which reappears again in Kirkcudbright, and passes through that county for more than twenty miles, its course can be traced for about fifty miles, including the interval which occurs between Glenkiln and Shawhead, in which it runs under the red sandstone of the lower portion of the vale of the Nith. The extent of the southerly band is much less than either of the other two, not exceeding five miles; but, as this one disappears under the red sandstone of the higher part of Annandale, and, if it reappears again on the opposite side of the vale, must occur amongst a series of Silurian rocks, considerably metamorphosed, its course as an anthracite bed and graptolitic shale must be much shortened westward. The length of these lines on the east, beyond the county of Dumfries, I have not yet been able to ascertain, not having examined the geology of Selkirkshire; but, from their appearance when they enter Dumfriesshire, it is probable that they traverse the whole of the country lying eastward, and their persistency is such, that it is by no means unlikely that they run through the whole of the Silurians of the south of Scotland, except when igneous rocks have interfered.

The position of these bands is probably attributable to a succession of faults, which run through the district in a direction parallel to the strike and range of the chain. The section at Glenkiln Burn

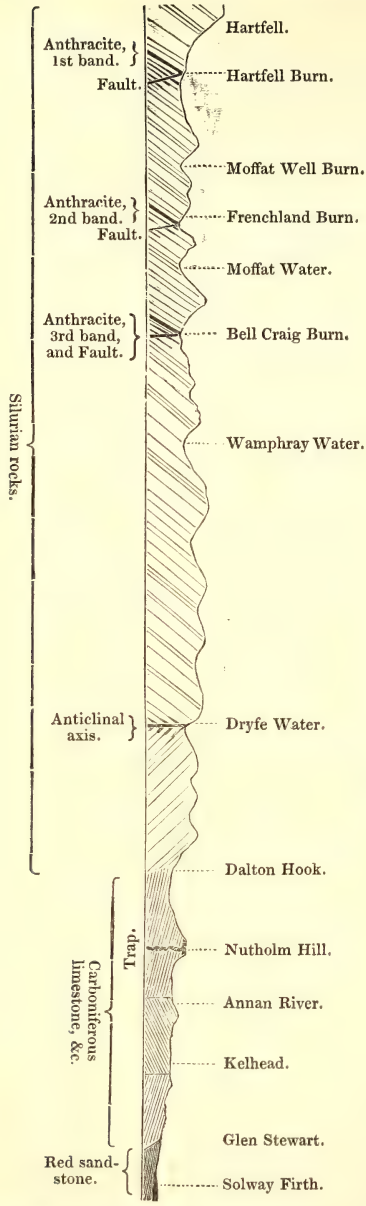

Fig. 1.—*Ideal Section from the Solway Firth to Hartfell, Dumfriesshire.* 30 miles.
(The Trap rocks of the Silurian Series are omitted.)

indicates that these traverse the Silurians at short distances from each other, the result of a repeated throwing-down of the strata in a N.N.W. direction. The effect of these faults has been to bring up at intervals the anthracite beds and the graptolite shales; the consequence being a repetition of the same beds in three parallel bands, as we have before seen.

In some cases the lines of fault appear to run immediately through parts of the anthracite beds, for we find these so affected as to show that they have been contiguous to the forces which produced the upheaval and depression of the strata; this is indicated by the flexures which the anthracite suffers, and the slickensided character of the dark-coloured shales. Many other faults, however, seem to occur which have not exposed the fossiliferous portion of this part of the Silurians. These are shown by the polished appearance which some of the faces of the finer beds of greywacke present, and which in some localities, more particularly when metamorphic action has been at work, have produced upon the faces of the rocks a black burnished aspect, similar to what would have resulted from the polishing of any smooth surface with plumbago. In the case of the more indurated rocks, these faults seem in general to have caused a sliding action of the strata along the planes of the beds, rather than a general breaking-up of the deposits; but in the case of the soft shales and the anthracite, there appears to have been considerable strain, by means of which these beds were broken up and contorted.

The almost constant effect of these faults has been to give the strata a N.N.W. dip. In some localities there are, however, inclinations varying from this; but these occupy a very small area, and are only indications of small local oscillations, and soon give place to the prevailing dip; and so general is the direction of the faults along the course of the strike, that in the Stewartry of Kirkcudbright, where igneous rocks abound from whence veins both of granite and porphyry emanate, the course of these veins is almost universally that of the range of the strata.

Having seen the intimate connection which exists between these fossiliferous bands, the question presents itself, as to what portion of the Silurians are they referable. The organisms which are found in the greatest quantities are *Graptolites*; and, since these are but low in the scale of *Radiata*, it is probable that they may have an extensive geological range, as we find *Graptolites Ludensis*, Murch., ranging from the Ludlow rocks to the Llandeilo flags. Some of these fossils appear to be more restricted in their position, and particularly that portion of the group which are foliaceous and have serratures on both sides. To these latter fully one half of the species which occur in Dumfriesshire appertain, and consequently they mark to a certain extent the position of the deposits in which they abound. Amongst the Irish Silurians in which *Graptolites* are met with, Colonel Portlock considers those beds which contain such as have serratures on one side only, as lying beneath the deposits which afford such as have a foliaceous character; and Prof. Nicol, applying the same principle to the graptolite beds of Peeblesshire, considers that the deposits at Grieston quarry in that county are referable to the Llandeilo flags, and that the beds described by Mr. Moore, and occurring in Wigtonshire, in which foliaceous *Graptolites* are found along with three species which have serratures only on one side, similar to some of those at Grieston, occupy a higher position than the Peeblesshire fossils. With regard to the Dumfriesshire *Graptolites*, they seem, with the exception of one or two species, to be distinct from any of those which have been procured either from Grieston or Wigtonshire; and, on the whole, the foliaceous group is so well developed, as to place them in a higher position than even those of the latter locality. I am, therefore, induced to consider the deposits which they occupy as the equivalents of the Caradoc sandstone.

The general mineral nature of the deposits which represent the Silurian rocks in this county consists of greywacke sandstone and indurated shales, as before stated. These are, however, with some slight modifications, the common characters of the whole of the Silurian formation in the south of Scotland, and have originated in the same causes which have produced the sandstones and shales of other geological formations.

Of the peculiar feature of this deposit in Dumfriesshire, viz., the anthracite bed and its overlying dark shales, the origin is not altogether evident. We find amongst none of the beds any traces of fossils to which can be referred the thick deposit of anthracite—no fucoids, nor any remains of vegetables of any description; and yet there can be little doubt that this substance is the result of some kind of vegetation which flourished during the epoch of the Caradoc sandstone.

Sir Roderick Murchison refers the anthracite schists of Scandinavia to large forests of *algæ* and *fuci* which originally existed in the Silurian seas of that region, and which have, "from their ready decomposition and the great changes which the sediments have undergone," lost all traces of their original forms. The large portion of carbon which is found in the dark shales above the anthracite, and to which they owe their colour, seems to corroborate the opinion as to the readiness with which fucoids may have been decomposed. Prof. Nicol has also found small fragments of this substance amongst the Grieston slates on which "some markings occur which may have been *algæ*"; but, from the ashes of the anthracite, he is disposed to refer the plants which have constituted it, to a higher class of vegetation than fucoids. Whatever may have been the origin of this anthracite, there can be no doubt that the deposits which immediately succeeded it had in the first instance the nature of black mud, and that this mud owed its composition in part to an addition of the remains of decomposed organisms. Such a muddy matrix doubtless afforded a suitable habitat for the *Graptolites*, the remains of which are now so plentifully entombed in it, and which, from the decomposition of the iron pyrites, into which they were converted, are now furnishing the chalybeate and saline-sulphureous springs of the county with their medicinal properties.

Silurian Fossils of Kirkcudbrightshire and the position in which they occur at the eastern entrance of Kirkcudbright Bay.

Some time ago Lord Selkirk presented the Geological Society with a suite of fossils which had been collected by Mr. Fleming, of the Kirkcudbright Academy, on the east side of the bay of Kirkcudbright, and these fossils were named by the Geological Survey.

The locality at which these fossils occur is called Balmae, and is at the point which marks the eastern termination of the bay. Here the remains are found in three different spots. The one furthest to the east, near the headland called Howell Point, affords a dark-coloured greywacke flagstone, in which one species of Graptolite is found in great profusion, to the exclusion of any other species; this appears to be the *G. Ludensis*, Murch. Amongst these, *Orthocerata* also are met with in considerable quantities, the species consisting of *O. Sedgwickii*, Forbes, *O. annulatum*, Sow., and *O. tenuicinctum*, Portlock. These are the only fossils which occur at this spot; the beds which lie above and below the fossiliferous strata consisting of the usual fine-grained greywacke sandstone.

A short distance to the westward of this, at a point called Gipsy Head, other fossils are to be found in strata which differ very materially from the usual beds of the Silurians of the district. The deposit here consists of a soft, grey, shivery shale, in which nodules of limestone abound, and in these nodules the fossils are commonly to be met with. A list of these fossils is given at page 206 of the fourth volume of the Quarterly Journal of the Geological Society. Since they were examined by Mr. Salter, three other fossils have been added by Mr. Fleming, which he had not then obtained—two species of *Favosites* and a *Catenipora*. This shale with its imbedded nodules is overlaid by thin-bedded, fine-grained greywacke sandstone, and a similar deposit occurs below it. Still further to the west, and within the entrance of the bay, another bed of fossils is found. The strata here are composed of dark greywacke flags, resembling those at Howell Point, and in these also Graptolites occur. The most common species is the *G. Ludensis*, Murch.; but along with it the *G. tænia*, Sow. and Salter, and *G. foliaceus*, Murch.?, both found in Wigtonshire, are met with.

The stratification of the Silurians in this neighbourhood is well-marked, the strike being in an east and west direction. The strata, however, are much confused as to dip, sometimes inclining northwards at a high angle, and at some places southward, with numerous instances of perpendicular strata in the intervals. The most prevailing dip appears to be towards the south, the nearer we approach the coast: the strata along the bay, being traversed by dikes of felspar-porphyry and trap, owe their confusion of dip to this circumstance. Taking the prevailing inclination as southward, we have, so far as the fossiliferous beds are concerned, first and lowest, a deposit containing three species of *Graptolites*, but from which other organic remains are excluded. This bed rests upon greywacke flags and sandstone of a light grey colour and more earthy character than the Dumfriesshire greywacke, and than that also which is met with in the more northerly parts of Kirkcudbright. These beds in their lower portions are intersected by numerous dikes of igneous rock. Above these lower graptolite flags we have greywacke sandstones and flags of considerable thickness, devoid of fossils; but resting on these is a soft grey shale, with limestone nodules, containing fossils of different kinds. Above this second bed the higher graptolite flags with *Orthocerata* occur, separated from the middle bed by greywacke flags and sandstones of comparatively little thickness. No beds superior to these are exposed; but to the east, near Netherlaw Point, the representatives of the mountain limestone are seen between the Silurians and the sea; and at Mullock Bay, near the point of contact of these two formations, Graptolites occur in the former rock, similar to those at Howell Point.

The general character of the fossils in the deposits about Balmae is such as to indicate an intimate relation between the Wenlock shales and this portion of the Silurian; and as the beds here are highly inclined, and as a considerable distance also occurs between the fossiliferous deposits and the porphyritic district on the north of the parish of Kirkcudbright, which is occupied by the Silurian formation traversed and altered by igneous rocks, it is probable that in this interval some of the representatives of the Lower Silurians may be found much metamorphosed, and deprived of all traces of organic remains.

Concluding Remarks on the Silurian Rocks of Dumfriesshire, and of the South of Scotland generally.

On the south side of the porphyritic district of Kirkcudbright the prevailing dip is southward; the same direction also obtains on the south side of the granite of Criffel, amongst the Silurian rocks. On the north side of these igneous masses the usual N.N.W. inclination occurs, and this inclination is the common dip of the stratified deposits of Kirkcudbrightshire, except where they are disturbed by the intrusion of igneous rocks. Following this south dip in an easterly direction we meet with it in Dumfriesshire, in the parishes of Torthorwald, Mousewald, Lochmaben, and Dalton, in which localities the Silurians have their southern limit. The range of hills here is distinctly marked by characters which show that some change takes place in the inclination, their steep and precipitous sides being towards the north with gentle slopes southward. At Barlouth, in the parish of Torthorwald, about a mile south of the high road, the dip is southward, at an angle of 75°, the rock consisting of a fine-grained greywacke, with intercalated shales, considerably metamorphosed, the shale being disposed to break at right angles to the planes of deposition rather than to split along the laminæ. At Cleugh Brae, in the parish of Mousewald, we have a section of the Silurians well shown in a small brook. Here the rock dips S.S.E. at an angle of 75°, and consists of the same altered shale and greywacke sandstone as occurs in the parish of Torthorwald. On the hills above Rammerscales, in the parish of Dalton, the same dip and rock prevail, and these may be traced eastward until they cross the river Annan at Linn Mills, where the strata are exposed, and have an inclination towards the south at an angle of 72°. At Lockerby, in the railway cutting, the same dip is seen, and from thence it appears to extend eastward along the course of the Silurians.

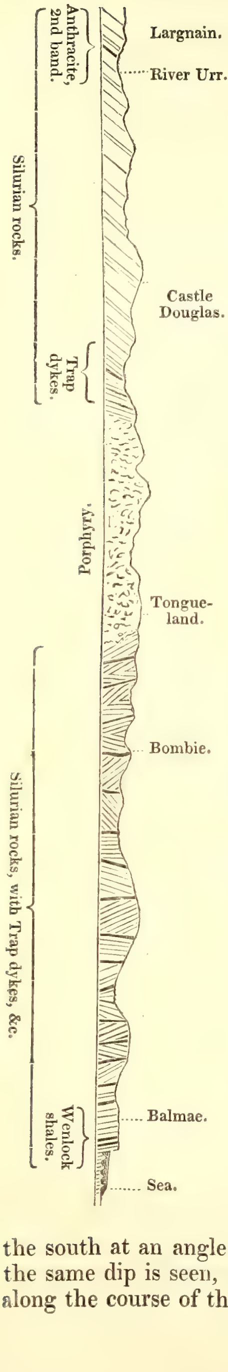

Fig. 2.—Ideal Section from the Coast at Balmae to Largnain, Kirkcudbrightshire. 18 miles.

From these south inclinations of the strata along the southern margin of the Silurians, and from the N.N.W. dips which succeed them on the north, it is evident that an anticlinal axis traverses the range near its southern extremity; and this axis seems to have resulted from the granitic eruption of Criffel, which has split the strata in an east and west direction, and elevated the deposits along this line of fracture. From the same cause, in all probability, originated the numerous faults which run along the equivalents of the Caradoc sandstone in Dumfriesshire. In that portion of the Silurian chain which occurs in the southern parts of Peeblesshire we have the south dip again prevailing; so that it appears that between the N.N.W. inclinations of Dumfriesshire and the south dips of the former county, there runs a synclinal axis; and according to Prof. Nicol, a northerly dip prevails along the northern boundary in Peeblesshire, showing the occurrence of a second anticlinal axis near the northern boundary of the Silurians in that county.

Many local variations from the usual inclinations are met with in different parts of the chain; one for instance is seen in Dumfriesshire, in the cutting of the Glasgow and South-western railway, about five miles east from Dumfries; and as this is the most southerly exposure of the Silurians in this county, the section is one of considerable interest. The railway here is cut through the southern base of an outlying hill, called the Howthat, which forms a spur from the general direction of the chain. Commencing at the west end of the cutting, we have beds of indurated shale, considerably metamorphosed, each bed being about three inches in thickness, dipping S.S.E. at an angle of 70°. This dip continues for some distance, and as we proceed eastwards the shale has thin beds of fine-grained greywacke sandstone intercalated in it, the faces of the sandstone being in many cases ripple-marked. These beds afterwards assume a perpendicular position, and soon the inclination is towards the N.N.W. at a high angle. Further east the beds again become perpendicular, and near the end of the section the strata show fine instances of flexures, which are succeeded by a S.S.E. dip.

Taking a general view of the Silurians of the south of Scotland, our present information would lead me to conclude that they afford the representatives of this system arranged as follows, viz.: On the south margin the Wenlock shales are indicated by the Balmae beds, which have a south dip. Then passing over a district occupied by the granitic axis, having on each side metamorphic rocks, we come upon the equivalents of the Caradoc sandstone, having a continuous N.N.W. dip, and appearing to extend through the central portion of the chain. To the north the Llandeilo flags are represented by the graptolite and trilobite beds of Peeblesshire, described by Professor Nicol.

With regard to the ages of the axes of this formation there exists considerable difficulty. The granitic and porphyritic eruptions of Galloway must have taken place after the deposition of the Wenlock shales, because this deposit has been thrown up by these igneous rocks; and, as we have no trace of this portion of the Silurians on the north, denudation may probably have removed it. It is likely, however, that at a comparatively recent geological epoch considerable changes have taken place amongst the Silurians of Dumfriesshire, for we find several small isolated patches of the red sandstone resting unconformably upon the former, the dip and position of which would lead us to conclude that during the formation of that deposit portions of the Silurians had been subjected to agencies which modified their original contour, and which gave to the overlying sandstone its isolated character.

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3. *Description of the* Graptolites *found in the* Black Shales *of* Dumfriesshire. By R. Harkness, Esq.

[Communicated by J. C. Moore, Esq., Sec. G.S.]

[With a Plate.]

The Graptolites occurring in Dumfriesshire present three well-marked generic types: 1st. Those which consist of a *single series* of cells, united together at the base, and also adhering along the sides nearly to the orifice of each cell,—the cells being attached in an oblique manner to the axis; to these the name *Graptolites* is by common consent applied, and they form the first section of that genus, *Monoprion*, according to the arrangement proposed lately by M. Barrande. 2nd. Those which have a foliaceous appearance, and in which the cells are in *two series*, arranged along a central axis,—features which characterize the genus *Diplograpsis* of M'Coy*, and the second section of Graptolites (*Diprion*) of Barrande. 3rd. Those in which the axis is reduced to a mere line, on which, at comparatively wide intervals, the cells are placed, and generally in a position but slightly inclined. The complete isolation of the cells is the distinguishing character of this genus, to which M. Barrande has given the name of *Rastrites*. All these three forms occur in the district under review.

Concerning the nature of Graptolites and their relation to modern species of zoophytes, it would appear from the general characters, that the foliaceous species (section *Diprion*, Barrande) are not far removed from the modern genera *Pennatula* and *Virgularia*. They possess, in common with these, a solid central axis, which in some cases is found extending much below the polype cells. A similar axis also occurs in the two genera mentioned, and the mode of arrangement of the cells in two series is also a common character. In the case of some species of *Diprion* there is a difference in the form

* At the Meeting of the British Association at Edinburgh, in July 1850, a list was read, drawn up by Prof. M'Coy, of fourteen species of Graptolites from the Silurian rocks of the south of Scotland. He has since kindly sent the plate in which his new species are figured, and enabled us to identify two of them with ours. It is thought that figures of the other species from this little-known district will not be unacceptable.

of the cells, according to the position which they occupy, an occurrence similar thereto being met with in the genus *Virgularia,* in which the cells near the base undergo considerable modification.

As regards *Graptolites* proper, and *Rastrites,* their existing analogues are not so well ascertained. On the whole, they appear not far removed from the modern genus *Sertularia,* and partake rather of the characters of hydroid than asteroid zoophytes *.

Rastrites, Barrande.

1. R. peregrinus, Barr.

Pl. I. fig. 1 (and 2 ?).

(Barrande, Grapt. Böhm. pl. 3. f. 10–13.) Syn. *G. spiralis,* Geinitz, Neues Jahrb. 1842, pl. 10. f. 28.

The extreme thinness of the portion on which the cells are placed is very characteristic of this species. It commonly appears devoid of any trace of a central canal, but occasionally an individual may be found in which a depression is seen, such as would result from the collapsing of the sides after the internal portion had been removed. It has generally a curved form, but (unless fig. 2 belong to the same species) only small portions have been obtained, and therefore the nature of the young part is uncertain. The cells, which are sometimes on the convex and sometimes on the concave side of the curve, are placed at right angles to the axis, and are far removed from each other. They are much thicker than the axis which supports them. In some rare cases they appear to increase in breadth from their base upwards; a character also represented in Geinitz's figure above quoted. A well-marked line runs along the length of each cell, the result of compression, the cells being hollow. In a line there occur about four cells, measuring at their base. The extremities of the cellules when these are situated on the convex side of the axis are remote, but when they occur on the concave side they are approximated to each other. This species is generally converted into iron pyrites, and shows no traces of its external envelope. The locality where it is found most commonly is in the course of the Little Queensberry Burn; but it likewise occurs in other parts of Dumfriesshire where the graptolite shale is met with.

Fig. 2 is in its inner or younger portion very like this species, see the magnified figure at 2 *b*; in the older part (2 *c*) the canal is broader; this specimen therefore seems intermediate between *R. peregrinus* and our next species.

2. R. triangulatus, Harkness.

Pl. I. fig. 3.

This species when perfect is spirally rolled, and the younger por-

* I have to express my obligations to M. Barrande and Mr. Salter, who have examined the Dumfriesshire Graptolites; and to whom I am indebted for many important observations concerning them.

tion shows some difference from the adult. At the apex the cellules are smaller and have a partially recurved form. In the adult portion they are directed outwards, and the axis seems to be broader than is common in this genus. This, however, is caused by the base of the cells being enlarged and brought near together. They grow rapidly narrower from the base to the opposite extremity, and have thus a triangular form, whence the specific name. A depression runs along each cell similar to that occurring in the preceding species.

In the adult portion the number of cells in *two lines* is five. Our specimens present a shining pyritous surface, and no trace of the external covering is manifest. This form is common in the shale of the Frenchland Burn near Moffat, and also at Bell Craig Linns.

Graptolites, Linnæus, Beck, &c.

1. Grapt. Sedgwickii, Portl.

Pl. I. fig. 4. Natural size and magnified.

(Portlock, Geol. Report, pl. 19. figs. 1, 2, 3, 6.)

Polypidom straight and of considerable length; the apex appearing to attenuate rapidly. The young portion seems to present no difference from the adult, except in having the cellules of smaller size. In well-preserved specimens a linear axis is seen running along the margin of the polypidom. The canal is about as broad as the teeth, which at their extremity are rounded, and turn slightly downwards. The mouths of the cellules are remote from each other, and from the lower part of them a long spine emanates. In an individual exceeding the twelfth of an inch in breadth, the number of cellules in an inch is twenty.

When in a good state of preservation, this fossil consists of carbonaceous matter having a shining appearance and smooth surface; it is met with in great abundance in the course of the Duff Kinnell, a small rivulet near Rae Hills, about twelve miles from Dumfries.

This is figured afresh, to show the long spine projecting from the tip of the cell. The form of the cells is not well shown in Portlock's figure. The original specimens have been compared with mine.

The possession of a spine gives this graptolite somewhat of the character of the *G. colonus* and *G. Halli* of Barrande. The length of the spine is greater than in either of these two.

2. Graptolites Becki, Barr.

Pl. I. fig. 5. Natural size and magnified.

(Barrande, *loc. cit.* pl. 3. fig. 14 to 18.)

G. lobiferus, McCoy, Ann. & Mag. Nat. Hist. vol. vi. 270; Cat. Woodwardian Museum, pl. 1B. fig. 3.

This graptolite is generally of great size; in one instance a specimen was traced which exceeded 18 inches in length, although neither the base nor the apex was discovered. The individuals which I have hitherto met with are straight, and some portions which are of smaller size appear to show that there is a gradual tapering towards the apex, the younger portion of the individual having the cellules of smaller size than the adult part. In the adult portion some traces may be detected on the dorsal margin of a fine axis, and the interval between this and the cells is about one half of the breadth of the latter. The cells are directed outwards, having a slight inclination upwards. They are adherent to each other only at their base, and as they proceed outwards their ends are distinct, a considerable space occurring between them. The cells narrow upwards, and then suddenly swell toward their termination into a rounded and curved knob, on the lower side of which is the mouth. No appendage is found at the extremity of the cells. In an individual exceeding a line in breadth, the number of cells was about twelve in an inch; in others of the same breadth this number was exceeded, and sometimes fewer occurred, the space separating them being of various breadths.

All the specimens of this graptolite were converted into iron pyrites, and the state of preservation is imperfect, the most common appearance being that of a white impression, the result of the decomposition of the sulphate of iron. The locality which affords it in greatest abundance is the Bell Craig Burn near Moffat.

3. Graptolites Nicoli, Harkness.

Pl. I. fig. 6. Natural size and magnified.

This species, which I have met with only in a fragmentary state, appears from its breadth to be of considerable size, and to have a straight form. The portions which I have obtained partake of the characters of the preceding species, from which it is distinguished only by the cells passing directly outwards, and having no inclination to the common canal, but being at right angles thereto. It wants also the pedunculated form of cell which marks *Grapt. Becki*, these being nearly of regular thickness from the base to near their rounded extremity. It is usually converted into iron pyrites, and imperfectly preserved, and occurs, in company with the preceding one, at the Bell Craig Burn; also at Glenkiln Burn, about seven miles north of Dumfries.

It is probable that the difference in the form and position of the cells above described are not sufficient to establish a specific distinction between this and the *G. Becki*, but it is thought worth while to figure it, as at least a remarkable variation.

4. Graptolites Nilssoni, Barr.

Pl. I. fig. 7. Natural size and magnified.

(Barrande, *loc. cit.* pl. 2. figs. 16, 17.)

In this species the polypidom is very thin, sometimes straight, and sometimes slightly curved. The specimens in my possession do not show the young portion. In some individuals traces of an axis are seen along the dorsal margin, and the space between this and the base of the cell is of greater breadth than the cellules themselves;

but usually the cells are at least equal to the canal in breadth, the latter showing a depressed line extending along its whole length, probably due to compression. The cells have an upward direction, and are very remote from each other, looking merely like notches at intervals along the edge. The upper edges of the cells are straight, and the opening apparently at right angles to the axis. The number of cells in an inch is about twenty, but there is a slight variation in different individuals, those which are curved having more cellules in a given space than those which are straight. It occurs in considerable quantities in a small brook which runs from the base of Little Queensberry. Here the shale has a styptic taste, owing to the decomposition of iron pyrites, of which this fossil is composed. Like the generality of pyritous fossils, there is no trace of the external covering.

The *Grapt. Nilssoni* of Barrande has such close resemblance, that we cannot apply a new name. It is quite possible that both this and the Bohemian species may belong to *G. tenuis*, Portlock, or at least to that figured as such by Hall (Palæont. New York); but Portlock's original specimen is quite indeterminable, and it seems best for the present to retain M. de Barrande's name.

5. Graptolites incisus, Harkness.

Pl. I. fig. 8. Natural size and magnified.

Prionotus sagittarius, Hisinger, Leth. Suec. t. 35, Supp. f. 6.?

Only a small portion of this species has been obtained, and that being only an impression, many of the characters are obscure. It seems to have been of large size and straight, with a well-developed axis. The space between this and the cells is very broad, exceeding that of any other species found in Dumfriesshire. The cells, which are imperfectly shown in the specimen, have an upward direction, and a very oblique position. The mouths of them are distant, but the ends are not distinctly shown; if a short spine projected from these, it would be difficult to separate this fragment from Hisinger's species. The number of cells in an inch is about eighteen, and the thickness of the interval between the cells and the dorsal margin is about the twelfth of an inch.

Locality. Bell Craig Burn near Moffat.

Besides these, there are two or three more species of this section tolerably abundant, but too imperfect to name.

Subgenus Diprion, Barrande (*Diplograpsis*, M'Coy).

1. D. pennatus, Harkness.

Pl. I. fig. 9. Natural size and magnified.

In this the central column is broad and slightly convex, with a central axis stronger and more prominent than is usual in the foliaceous Graptolites. Only a portion of the fossil is seen, neither its lower nor upper extremity being shown. As no attenuation is visible, it is probably of considerable size. The thickness of the central canal exceeds the breadth of the cells, and these are directed outwards and strongly recurved, their mouths distant; the number of them in an inch is about twenty, and they are well separated from each other. The external covering appears to have been smooth, portions of shining carbonaceous matter being found on its surface. It is of rare occurrence in the Duff Kinnell, associated with the *G. Sedgwickii.* It is somewhat like the *D. pristis* of Portlock, with which it has been compared, but that species has much closer cells, and they are not recurved.

2. D. NODOSUS, Harkness.

Pl. I. fig. 10. Natural size and magnified.

In this species the polypidom is rectilinear and flattened, and is but slightly attenuated towards the apex, the upper portion differing but little from the lower. The axis occupying the middle of the central column is well-developed and comparatively strong, and the space separating the two series of cells appears in a great measure to be filled up by it. The breadth of the central column is less than that of the cells, which are directed outwards, and have the mouths widely separated from each other. The base of the cells is broader than the mouth, which is rounded, and a marginal depression occurs just within the edge of the cells, perhaps due to the state of preservation. The number of cells in an inch is about sixteen, and the breadth of the polypidom in the adult portion, including the cells, exceeds the twelfth of an inch.

This species is converted into iron pyrites, and the nature of the external surface is not evident. It is rare, the only locality in which I have found it being in the course of the Bran Burn, about thirteen miles north of Dumfries.

3. D. RECTANGULARIS, M'Coy.

Pl. I. fig. 11. Natural size and magnified.

(M'Coy, Catalogue of the Woodwardian Museum, pl. 1 B.)

We have only fragments, though these are abundant, of a species resembling in the outline of the cells the species above quoted.

Localities. Frenchland Burn, Moffat, and other places.

4. D. FOLIUM, Hisinger, sp.

Pl. I. fig. 12. Natural size and magnified.

(Hisinger, Leth. Suec. tab. 35. Supp. fig. 8.)

This pretty species, in the close approximation of the cells and their general direction, is very like the species above quoted, but the length of the individual cells is not so great, and our specimens are consequently not so broad and obtuse as the Swedish species. Hisinger's figure does not show the close-set lines which traverse the cells in the direction of the growth; but these appearances may be due to different degrees of preservation, and Mr. Salter has seen specimens of *D. folium* in which they are quite conspicuous, and believes the species identical.

Locality. Little Queensberry.

5. D. foliaceus, Murchison, sp.?

Pl. I. fig. 13. Natural size.

(Murchison, Sil. Syst. pl. 26. f. 3?) *G. folium*, Salter, Geol. Journ. vol. v. pl. 1. f. 5. See also *G. palmeus*, Barrande, *loc. cit.* pl. 3. f. 1–7.

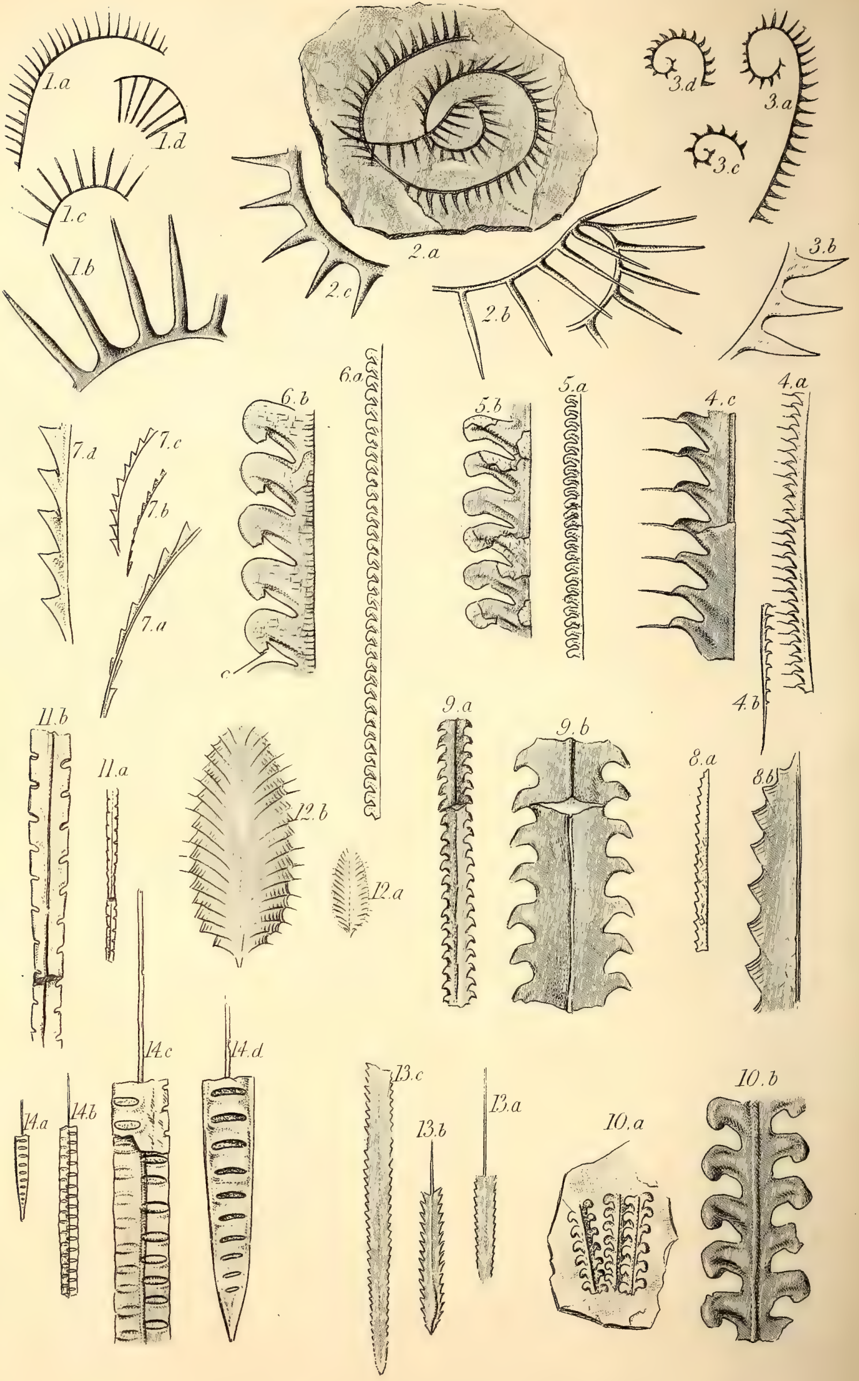
This form is subject to great variations, more particularly as regards its relative breadth and length. Many of the Dumfriesshire specimens have a fusiform appearance, and their breadth generally exceeds those figured by M. Barrande *. In an individual specimen of about three-fourths of an inch in length, the total breadth where widest exceeded one-fifth of an inch. In some instances the apex does not terminate by tapering, but abruptly. The central axis, although but thin, is commonly very distinct; and it appears to have been somewhat flattened. There is properly speaking no space between this axis and the base of the cells, which seem to take their rise immediately from the side of the axis; they are directed upwards and adhere to each other through their whole length. Their mouths are distinct and straight, and have no appendage attached thereto. The number of cells in a *line* is three, and this distance appears uniform both at the base and apex. The nature of the external covering of this species, at least from the Dumfriesshire specimens, cannot be determined, owing to the fossils being in the form of iron pyrites. The species occurs in great abundance both at Dobbs Linn, and also at the base of Hartfell, where it is associated with the preceding.

Scalariform or edge views of this or other species.

Pl. I. fig. 14.

Independent of the variations to which the last species is subject, there are other circumstances which, in common with all others of this genus, greatly modify it. These are in general the result of the fossil being crushed in such a manner as to give a lateral view. From this we have the various scalariform appearances on which have been founded such species as *G. scalaris*, Linn., but which M. Barrande in his 'Graptolites de Bohème' has shown to be only modifications arising from lateral pressure. Prof. M'Coy had also independently arrived at the same conclusion, which he lately published in the 'Annals and Mag. of Nat. Hist.' vol. vi. p. 272*.

* The *G. foliaceus*, Murchison, is so imperfect a specimen, that it is almost useless to refer to it till better specimens be discovered in the same locality.



Lower Silurian Graptolites. Dumfriesshire.

J. W. Salter del. J. De C. Sowerby sc.

EXPLANATION OF PLATE I.

Figs. 1 *c* & 1 *d*, and Figs. 3 *c* & 3 *d*, are from Mr. Harkness's drawings; the rest are engraved from the specimens.

Fig. 1 *a—d*. *Rastrites peregrinus*. 1 *b*, cells magnified; 1 *c* & *d*, from Mr. Harkness's drawings, are slightly enlarged.
Fig. 2 *a—c*. *R. peregrinus*? In this the young part, magnified at 2 *b*, has distant and linear cells; in the adult part, magnified at 2 *c*, the axis is thick, and the cells more like the next species.
Fig. 3 *a—d*. *R. triangulatus*. 3 *b*, a portion magnified.
Fig. 4 *a—c*. *Graptolites* (*Monoprion*) *Sedgwickii*. 4 *c*, a portion magnified.
Fig. 5 *a*, *b*. *G. Becki*. 5 *b*, a portion magnified.
Fig. 6 *a*, *b*. *G. Nicoli*. The magnified portion (6 *b*), shows the mouth at *c*, after the observations of Mr. Salter.
Fig. 7 *a—d*. *G. Nilssoni*. 7 *a* & *d*, magnified portions; in 7 *a* & *b* the stem is twisted, so as to show the teeth on opposite sides.
Fig. 8 *a*, *b*. *G. incisus*. 8 *b*, magnified portion.
Fig. 9 *a*, *b*. *G.* (*Diprion*) *pennatus*. 9 *b*, magnified portion.
Fig. 10 *a*, *b*. *G. nodosus*. The specimen is very obscure. 10 *b*, magnified portion.
Fig. 11 *a*, *b*. *G. bicornis*? The specimen is good, though much compressed. 11 *b*, magnified portion.
Fig. 12 *a*, *b*. *G. folium*, Hisinger. Narrow variety. 12 *b*, magnified.
Fig. 13 *a—c*. *G. foliaceus*? Specimens, natural size, showing the axis partly denuded of its cells. The specimens are mere pyritous stains, and the shape of the cells obscure.
Fig. 14 *a—d*. *G.* (*Diprion*), sp. 14 *d*, a magnified base, showing the mouths of the cells in a lateral view; in *b* & *c* the specimen is crushed obliquely, and shows on the right side the distinct casts of the cell-mouths; on the left the impressions are faint, being made through the substance of the fossil itself.

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4. *Notice of the* Coal-mines *near* Erzeroom*.

[Communicated from the Foreign Office, by order of Viscount Palmerston.]

The coal district lately discovered near Oltoo†, and since visited by MM. Brant and Wiet, the English and French Consuls resident at Erzeroom, is about sixteen hours (at least fifty miles) distant from the latter place by the shortest route. The country is very mountainous, and almost impassable even for the native ox-carts.

The strata of the district are much disturbed. The coal was seen at two places where pits had been sunk on the mountain-side. One bed, from 12 to 16 feet thick, composed of alternating layers of rock and coal, the former predominating, runs E. and W., dipping rapidly to the S.E. Higher up the mountain another similar bed, 4 feet thick, was seen running N. and S. and dipping perpendicularly.

The coal is black, lustrous, very brittle, and emits a strong smell in burning. It is probably abundant, but, from its friability, the difficulty of separating it from the matrix, its doubtful quality, as well as the difficulty and expense of working and transporting it, it is very doubtful whether the discovery of this coal will at present prove of any utility.

* See Quart. Journ. Geol. Soc. vol. vi. p. 367.
† N.W. of Erzeroom, and about 40° 30′ N. lat., 41° 50′ E. long.

December 18, 1850.

The following communications were read :—

1. *Notice of the discovery of a* New Combustible Substance *in* Russia.

[Communicated from the Foreign Office, by order of Viscount Palmerston.]

A combustible substance, named 'Pungernite' by M. Bulgarine, has been found in the Silurian formation between Rana-Pungern and Gross-Pungern, on the road from Dorpat to Narva, in Esthonia. It occurs in the form of a yellowish brown, laminated layer, speckled with white, very light, and as hard as coal. It burns freely and brightly, giving off a great quantity of soot. According to M. Petzoldt*, its constituents are—

Organic matter	65·5
Silica	13·6
Oxide of iron and alumina	2·3
Carbonate of lime	17·0
Carbonate of magnesia	0·2
Water	1·2
	99·8

2. *On the* Epiolitic Rocks *of the* Venetian Alps. By Prof. T. A. Catullo.

[In a Letter to Sir Roderick Impey Murchison, V.P.G.S.]

Prefatory Remarks by Sir R. I. Murchison.—In communicating, at his own request, this memoir of Professor Catullo, I must be permitted to state, that, with every wish to do him justice, I do not coincide in his views. The allusions I made to Professor Catullo in the Sketch of the Alps and Apennines (Quart. Journ. Geol. Soc. vol. v.) referred to opinions maintained by him in 1847 at the Scientific Congress of Venice, and I could not be supposed to be cognizant of his having since adopted the same ideas as his adversaries. The zoological portion of his paper must be left to the consideration of M. Leopold v. Buch and M. de Zigno, who have studied the fossils. On points more immediately touching myself, I need scarcely remind the reader that the Permian Flora is not common to several formations—that the Flysch or Macigno is not the equivalent of the Scaglia; the first being a tertiary, the last a secondary formation. My belief is in no way affected by this memoir, and I now hold, as I did in 1848, that the rocks which Professor Catullo has termed *Epi*-olitic, when separated from the Neocomian, are simply the representatives of the Oxfordian group.

Being unaware of the changes I have introduced since the publication of my 'Prodromus'†, and within the last three years, you are still‡

* L'Abeille du Nord.

† Prodromo di Geognosia Paleozoica delle Alpi Venete.

‡ Quart. Journ. Geol. Soc. vol. v. p. 179.

under the persuasion, that there is a difference of opinion existing as regards the situation I have assigned to the red ammonitic limestone; whereas having gone over the old classification of the cretaceous system which I proposed in my work on Fossil Zoology, published in 1827, I find now that I perfectly agree with the great proportion of geologists. Nor, in doing so, do I find that I contradict any of the deductions I have been able to gather from the observations I have already published in my other works; for besides having always attended to the facts offered to me by palæontology, even when they disagreed with the classification of formations I had adopted*, I took especial care to direct my attention to the species that are most constantly found, and in the greatest abundance, within the limits of a given formation, and to attribute to them their due value. I say *the greatest number of individuals,* because it sometimes happens that a few are met with out of their usual position, and mixed up with individuals of species more or less ancient than the deposit to which the former belong. This fact was first announced by the elder Brongniart†, and has been mentioned by many other geologists‡; it is well known what discussions were occasioned at a meeting of the Geological Society of France, by Fitton's discovery that that *Ammonites Deshayesii,* Leym., which abounds in the inferior chalk of the Caucasus, and other fossil species belonging to the gault, are found likewise in the neocomian limestone of England (meeting of the 21st May, 1844). This is the case with the *Ammonites fascicularis,* D'Orbigny, and with a few other cretaceous species which I found in that division of the red ammonitic limestone, which I now propose to distinguish by a new name, as I shall presently show. It is sufficient to glance over the history of the palæontological observations that have been made during the last few years, to learn that the mixture of ancient fossils (not only the remains of animals but those of plants) with those of more modern formations is a fact that does not admit of dispute. The rocks of the *Permian* period, as you well know, contain different floræ; that is to say, they may be found in several formations, and the flora of the *Keuper* is so distinct from the flora of the *Grès bigarré,* as not to present any palæontological analogy with the other divisions of the *Trias,* with which it has been associated§. As regards the few species of *Ammonites* which I persist in considering as common to many formations, I must beg you, Sir, to consider that a course of thirty-eight years of observation, and that too in places not yet examined by any other geologist, ought to inspire more confidence than can be placed in one who, wanting this requisite, supports the contrary. The red limestones occupy a great extent of country, and belong partly to the jurassic system and partly to the cretaceous. In the first case, when they belong to the jurassic system, they constitute a most important group of rocks, distinguished by the epithet of [Sopra-jurassico] upper-jurassic [?]; because, in

* Zoologia Fossile, p. 263, Padua, 1827, 4to.
† Annales des Mines, 1821.
‡ Société Géologique de France, 18 Juin, 1843.
§ Institut, Oct. 1849.

fact, they have for their uppermost limit a red limestone, sometimes schistose, sometimes arenaceous, which underlies the neocomian limestone, and which often rises to considerable elevations, covering with its more or less inclined strata the beds of compact red limestone which are always inferior to it. The red limestones of the second group are usually separated; the beds of the one alternating with the beds of the white or yellowish neocomian limestone, which contain the same fossils; while the invariably thin strata of the other are sometimes red, sometimes grey, and represent the *Flysch* of the Swiss, the *Macigno* of the Tuscans, and also, according to you, the *Carpathian sandstone*; in a word, they represent the *Scaglia* of the Venetian geologists, with which (in the descending order) the chalk formation begins. I shall only occupy myself at present with the first two limestones of which I have spoken above, which although till now they have been confused together under the single name of *red ammonitic limestone,* deserve however, as you will see, to be distinguished from one another.

As regards the geographical distribution of the ammonitic limestone, Baron von Buch observes, that it forms a most extensive zone, which touches the Crimea on the one side, and Mount Tatra in Poland on the other, and which extends to the west as far as the French Jura. He afterwards mentions that the *Ammonites Tatricus,* Pusch, the *Terebratula diphya*, Buch, and some species of *Aptychus,* are the fossils which more particularly characterize this formation. In Italy the same rock is in like manner prolonged through an extensive tract of country; it begins near the confines of the German Tyrol (Stua in the district of Cortina d'Ampezzo), throwing out its branches to the foot of the Dolomitic Alps of Agorda (Celo, Colazzo, &c.), and stretching in various directions; towards the west it extends into the district of Feltre (Cesio, Fastro, not far from Arsie), and advances into the Setti Comuni (Rotzo, Castelletto, Cesuna) and into the Veronese territory (le Sine); and towards the east it extends above Belluno (Igne, Pirago, Lavazzo, &c.) where it is quarried for building-stone. In Lombardy it reappears under the same conditions (Arbe, Suello, Trescorre, Entratico), but from thence it does not spread into Piedmont; whereas in Tuscany, Umbria, Modena, and Liguria, it constitutes a well-marked formation. In fact, the compact red ammonitic limestone lying under the red schistose limestone of Parodi, described by Pilla, and that of the territory of Perugia, and of the whole length of the Spoleto mountains, are both characterized by the same fossils which we have collected in a long succession of years in the mountains of Lombardy and Venice, and which, with the exception of a few species, do not differ from the fossils contained in the red limestones of Liguria.

Epiolitic Red Limestones of the Upper Jurassic group.

This group, in those places where it has acquired its full development, rises in extensive mountains, of a nearly constant form, presenting slopes more or less steep on one side, especially in the upper third part of their height, and forming on the opposite side inclined ledges, as well as table-lands (plateaux), sometimes nearly horizontal (southern slopes of Monte Valdart in the district of Belluna). This formation may, as we have said, be considered to be composed of two distinct limestones; one of which does not everywhere preserve the same characters, but presents a diversity of colour and structure; while the other, which covers the former, is almost always of a dark red, sometimes approaching to yellowish, although in some places it loses the arenaceous appearance and assumes the schistose structure, and it is then that, when moistened by the breath, it gives out a strong argillaceous odour. In various places the inclination of the strata of both these limestones is as much as from 40 to 45 degrees (between Igne and Pirago in the district of Belluna), while in other places the strata are somewhat less steep, and sometimes even lie in a position little removed from the horizontal (Fastro, not far from Cismone in the Feltrino, Lavazzo, &c.). I call the first of the above-mentioned rocks *the inferior epiolitic limestone*, and I distinguish the second from it by the name of *the superior epiolitic limestone*; by which I endeavour to rectify the mistakes that have naturally arisen from considering these rocks as belonging to one and the same formation. This distinction, partly mineralogical and partly geognostical, naturally leads one to suppose that the greater or less adhesion of the fossils of the said limestone depends on the mineralogical character of the rock; for those found in the schistose limestone, enclosed as they are in a marly coating, are easily disengaged; while the fossils of the lower limestone (which is always compact and admits of a polish) adhere to it so closely that they may be said to be almost incorporated with it.

Lower Epiolitic Limestone of the Venetian Alps.

I beg you, Sir, to direct your attention for a moment to the fossils contained in the oldest of these limestones, making the different *Ammonites* that are peculiar to them your especial guide, and passing over for the present the remains of animals of other genera that pass from the level of this rock to that of the superincumbent rocks.

If the *Ammonites Fontana*, the *Ammonites Toblinianus*, and other species of the same genus, which I believe to be unpublished, were not found associated with some few others already published by D'Orbigny, I should not be able, guided by them alone, to pronounce any judgement on the age of the limestone containing them; but their being fortunately associated with well-known species authorizes me to believe them to belong to a formation anterior to that of the schistose limestone, with which it has been confused.

Ammonites perarmatus, Sow., *A. annulatus*, Sow., *A. biplex*, Sow., and *A. linguiferus*, D'Orbigny, are well-known species that might throw some light on the matter in question, if it were not that in some countries they are found existing in formations belonging to different periods. In fact, *Ammonites perarmatus* and *A. biplex* have been found by the Baron von Buch in the coralline limestone of Switzerland, which is considered to be coeval with the coral rag; *Ammonites linguiferus* has been referred by D'Orbigny to the lower oolite of the Vendée and of other districts of France, while *Ammonites annulatus* (which is not to be confounded with the species of the same name described by Schlotheim) belongs, according to Sowerby (Mineral Conchology), to the lower lias, and according to D'Orbigny, to the upper lias, which last would be equivalent to our *upper epiolitic limestone*.

Ammonites of the Inferior Epiolitic Limestone.

Ammonites perarmatus*, *Sow.* tab. 1. fig. 4.
—— biplex, *Sow.* tab. 11. fig. 3 *a, b*.
—— annulatus, *Sow.* tab. 11. fig. 2 *a, b*.
—— linguiferus, *d'Orb.* tab. 1. fig. 2 *a, b*.
—— Fontana, *Cat.* tab. 2. fig. 1 *a, b*.
—— Toblinianus, *Cat.* tab. 2. fig. 4 *a, b*.
—— strictus, *Cat.* tab. 4. fig. 2 *a, b*.
—— Albertinus, *Cat.* tab. 2. fig. 3 *a, b*.
—— quinquecostatus, *Cat.* tab. 3. fig. 8.
—— contiguus, *Cat.* tab. 4. fig. 2 *a, b*.
—— Benianus, *Cat.* tab. 2. fig. *a, b*.
—— exornatus, *Cat.*

You, Sir, have placed the limestones, of which we are speaking, in the second group of the Jura-system, consisting of the Oxfordian rocks†, and not rather in the first group, which embraces the Portland limestones, which may be in fact considered as the true representatives of the upper jurassic formations of Brongniart, to which the chalk-formation immediately succeeds. Without involving myself in discussions, in order to decide to which of the three groups the epiolitic formation of the Venetian Alps belongs, I shall only observe that some of its fossils have their equivalents in the coral rag, which is one of the members of the upper group established by the English school. The reasons that forbid our considering the inferior part of the said group as an equivalent of the coral rag, have been given by you in your "Sketch of the Oolitic Formations of Germany‡."

If, from the position of the lower red limestones of the Venetian territory, we may conjecture that they are nearly allied to the coralline limestone of other countries; on the other hand, they differ from it by being destitute of zoophytes. The few that I possess, and of which I shall give figures in the work on Fossil Zoophytes that I have now ready for the press, may be referred to the order of *Spongiaria*, and they come from the *upper epiolitic limestone* of the district of Bergamo.

The other fossils, besides *Ammonites*, occurring in the rocks of which we are speaking, are various species of the genus *Inoceramus*,

* These species I have always found in the lower beds of the Epiolitic formation, and are figured and described by me. Plates 1, 2, 3, 4, are still unpublished; the others are inserted in the 'Prodromus,' 1847.

† Quart. Journ. Geol. Soc. vol. v. 1849.

‡ Proceedings of the Geological Society, May 1831. Sir R. I. Murchison desires the Editor Q. G. J. to observe, that he has long since abandoned this opinion.

some of which we also find in the upper neocomian strata; the teeth of *Lamna longidens?*, Agass., of *Ptychodus latissimus*, Agass., of *P. Mortonii*, Agass., and *P. mammillaris*, Agass.; and among the remains of Saurians, the skull of a Crocodile, from the ammonitic limestone of Tresche in the Sette Comuni, already described by Sternberg*, and compared by Cuvier to the *Gavialis longirostris*, Goldf., of the jurassic rocks of Honfleur in Normandy; which afforded me occasion some years ago to dwell on the similarity between the marl of Havre in France and the strata of the ammonitic limestone of the Upper Vicentine †.

What is important to observe is, that the *Terebratula antinomia*, Cat., so frequent in the upper epiolitic limestone and in the Biancone which covers it, does not appear in the limestone of the inferior bed; a circumstance which deserves to be recorded, because it contributes to establish the difference between these two limestones. Specimens, however, of this *Terebratula*, procured from the neocomian strata and from the underlying epiolitic schistose limestone, present varieties which will be noticed presently.

Upper Epiolitic Limestone of the Venetian Alps.

The upper epiolitic limestone shows itself with all its usual characters in many parts of Lombardy and the Venetian territory. In the district of Belluno it constitutes the upper part of the Alps which lie to the left of the Piave, opposite to the village of Longarone (Monte Salta); and the same formation rises on the right of the same river between Pirago and Igne, forming the right side of the road leading to Zoldiano.

The true epiolitic limestone is wanting in the neighbourhood of Belluno, for it must not be confounded with the red *Scaglia with fucoids*, which leans against the south slope of Monte Serva; but it appears that in the neighbourhood of Igne it bends to the north-west (Perera, Soffranco), and towards the south it is covered by the neocomian formation (to the right of the Piave), and by the eocene and miocene sandstones (Valle dell' Ardo); it then rises near Vedana approaching the Mis, and advancing into the district of Feltre (Cesio maggiore, Vedana). There, more than anywhere else, the epiolitic formation may be seen with all its geognostical and mineralogical characters, inasmuch as we see that the red limestone is in its upper part schistose, soft and marly, while the limestone of the lower strata appears compact, very solid, being of a dark red, with yellowish white spots; and in the lowest parts of the Alps it becomes a species of conglomerate, the nodules of which are connected together, and present nearly the same forms as the spots that are observed on the unaltered stone. The opinion that I have long since expressed, that these nodules are fragments of Ammonites, remains unchanged, inasmuch as the marks on the pieces of stone that are quarried at Cesio, to be worked into columns or tables, preserve the spiral forms,

* Voyage en Tyrol, &c. Ratisbonne, 1806.
† Zool. Foss. delle Venete, p. 190, 1827.

as well as the marks of the septa, and these are more clearly seen in proportion to the polish the stone receives.

In order to see better the relations that the red limestones of the epiolitic formation have with one another, it is necessary to cross the Mis, and look to the left of the torrent between St. Giuliana and the Rosse Alte, not far from Vedana. At the foot of the mountain the strata of the conglomerate may be observed; and these, being parallel to those of the red ammonitic limestone, which lies over them, appear to form with it one and the same deposit. The *upper epiolitic limestone* reappears towards the top of the mountain, and does not differ much in its appearance from the limestone of Igne, to which it is parallel, although it exhibits a more arenaceous appearance, and is less rich in fossils. Above this limestone, near the Rosse Alte, rise the beds of the chalk*, which at the first glance would seem to form a passage from the neocomian limestone of Alpago to the oolite limestone, if the grains, irregularly scattered through its mass, were not discovered to be organic remains similar to those we have remarked in the hippuritic neocomian limestone of the Pine and of the Tambre in Alpago†.

I shall give, some time or other, more circumstantial details of the peculiarities I have observed in the two epiolitic limestones, in those places in which I have been able to study them; but at present I shall confine myself to saying, that they sometimes cover, and sometimes flank, the dolomitic formation; but they oftener constitute by themselves alone the base upon which the cretaceous formation rests. I remark here, in passing, that where the dolomite rises to great heights, it never is covered by the epiolitic group, as some are inclined to suppose, but appears instead to be crowned by more modern rocks. The red limestones which we observe on the dolomitic summits of the Valley of the Brenta belong to the neocomian formation, and not to the epiolitic, or Oxfordian (as it is called by some). To the same formation belong the regular beds of red limestone interstrati-

Figs. 1 & 2.—*Sections of the Red Ammonitic Limestones.*

Fig. 1.

Camporotondo, Evera, &c.

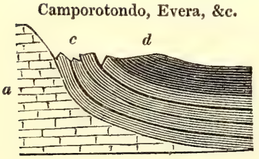
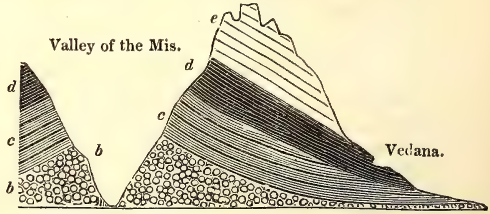


Fig. 2. Rosse Alte.



a. Dolomite.
b. Ammonitic conglomerate.
c. Inferior epiolitic limestone.
d. Superior epiolitic limestone.
e. Neocomian ? limestone.

* This white limestone, entirely free from flint, is quarried for the purpose of being made into tubes of various lengths and of the diameter of half a foot, which are to be substituted for the tubes of larch wood, hitherto used, for bringing to Belluno the water of the springs of Fistere.

† Memoria sopra le caverne delle Alpi Venete, p. 14.

fied with *biancone*, which I observed near the eminence of the Piano della Fagazza in Vallarsa†, and those also which I observed some years back in a valley (Valgadena) which runs into the valley of the Brenta‡.

Thus in the upper epiolitic limestones of the district of Feltre (not far from Cesio), as also in that of Cesuno near Tresche (Sette Comuni), of Entratico in the district of Bergamo, and of Perugia in Romagna, individuals of the *Terebratula antinomia* are found, which, as I have observed, have different forms from those which I have hitherto remarked in the individuals from the neocomian limestones (red as well as white) of the Tyrol (Fondo), of the Vicentine, and of the Veronese. The same difference of form I have also remarked in individuals of the same species, collected by Professor Pilla in the schistose limestone of Spezia, where it exists associated with *Ammonites Tatricus* and some *Nerinææ* peculiar to the upper jurassic system.

The dark red schistose limestone of Spezia, to the palæontology of which we have just alluded, may serve as a geological horizon with which to compare the analogous limestones of Lombardy, Tuscany, and the Alps of Spoleto, already considered by Von Buch as rocks belonging to the upper-jurassic period. This opinion, coming from the Nestor of European geologists, has had a favourable reception from the learned of all nations; therefore the author of an article inserted in the Bulletin of the Geological Society of France has committed an error in classifying the limestone of Spezia as the lower lias, because, mistaking the highest part of the jurassic formation for the lowest, he was obliged to consider the saline marbles of Carrara and Campiglia as rocks of the Devonian system, and, what is more to our purpose, to sink the schists which underlie the same marbles into the depths of the Cambrian system.

Among the fossils of the upper epiolitic limestone, I have found associated many species belonging to the neocomian formation, viz. *Ammonites bicurvatus*, Michelin, *A. simplus*, D'Orbigny, and *A. fascicularis*, D'Orbigny, *Crioceras Villiersianus*, D'Orbigny, and a few *Terebratulæ*, most of which may be referred to the *cinctæ* group of Von Buch.

Ammonites of the Upper Epiolitic Limestone.

*Ammonites pulchellus ?, *D'Orb.*
*—— simplus, *D'Orb.*
*—— helius, *D'Orb.*
—— emaciatus, *Cat.*
—— bifrons, *Bruguière.*
—— Tatricus, *Pusch.*
—— sub-Beudanti, *Cat.*

Ammonites bicingulatus, *Cat.*
—— bicurvatus, *Michelin.*
—— Capitanei, *Cat.*
—— Venantii, *Cat.*
—— Doderleinianus, *Cat.*
Hamites Labatii, *Cat.*

† Prodromo, p. 103.

‡ Zoologia Fossile, pp. 89, 98.

* The species marked with an asterisk are repeated in the beds of the neocomian formation, while the others belong exclusively to the formation in which they are found imbedded.

Remarks on the Terebratula diphya, &c.

Among the *Terebratulæ* is *T. antinomia,* Cat., described and represented in the 'Zoologia Fossile,' which appeared in print in the year 1827*. Some years afterwards the Baron von Buch took into consideration what I had written on this singular brachiopod; but, not being aware of the figures of other examples I had given† in 1828, only speaks of those which under different aspects I had published in plate 5 of the 'Zoologia Fossile,' printed the year before.

The Baron von Buch persists in considering the *Terebratula deltoidea, T. triquetra,* and *T. antinomia,* as merely varieties of the *Terebratula diphya,* which has not hitherto been found by any modern naturalist, but which we find only figured in the 'Ecphrasis stirpium minus cognitarum' of Fabio Colonna, published in 1616: to this union of species I made a vigorous opposition in a paper, accompanied by figures, which has been inserted in the fifth volume of the 'Proceedings of the Academy of Padua' for the year 1838.

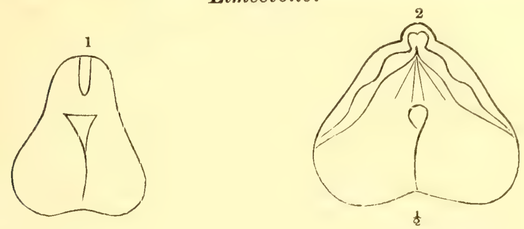
Subsequently I sent to the French palæontologists drawings and originals of the *Terebratula antinomia,* in order that they might tell me what they thought of the new species that I was proposing to add to the genus *Terebratula,* and M. Buchard, the same naturalist who found, not long ago, the necessity of separating the *Terebratula pumila* of Lamarck from the *Terebratulæ,* to place it (contrary to the opinion of Von Buch) in the genus *Magas* of Sowerby‡, writes to me on this subject in the following terms:—"As regards the *Terebratulæ deltoidea, diphya,* and *antinomia,* I entirely concur in your opinion, and I am, like you, convinced that there are several species, of which, on account of the manner in which they are pierced near the centre, we may form a charming group."

Von Buch, on the other hand, is of opinion that the *Terebratulæ* which have a longitudinal incision, as is the case with the species above-mentioned (and consequently also all those lately published by Prof. Zeuschner of Cracow), must be considered as individuals of *Terebr. diphya,* whatever may be the form of the dilated part of the furrow, and of the dorsal and ventral perforations. I, on the contrary, have satisfied myself, that the more or less deep furrow on the back, and the presence of the dorsal and ventral perforations, are characters which may serve to establish the genus that I have called *Antinomia*; while the different forms, as well of the furrow as of the perforation, and the shape of the base, sometimes angular, sometimes round, will afford excellent specific distinctions. And I am the rather induced to admit these distinctions, because there are some of these forms which are never found save within the limits of the neocomian formation, while there are others entirely confined to the upper epiolitic limestones. Guided by these principles, I propose, for the neocomian formation, the species *Antinomia diphya, A. deltoidea,* and *A. triquetra*; and I refer to the epiolitic limestone the *Antinomia*

* Page 169. tab. 5. figs. *p, q, r*.
† Gli Annali delle Scienze Naturali di Bologna, 1828.
‡ Bull. de la Soc. Géol., Séance du 17 Juin, 1848.

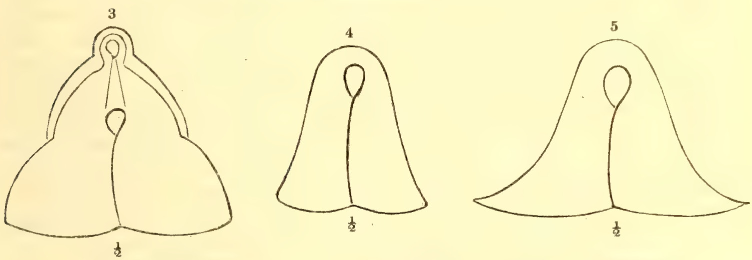
angulata, A. angusta, and *A. dilatata*, of which I intend to give the figures on another occasion. At present I exhibit only an outline of each (see figs. 3 & 4).

Fig. 3.—*Species of Antinomia belonging to the Neocomian Limestone.*



1. Antinomia diphya. 2. A. deltoidea.

Fig. 4.—*Species of Antinomia belonging to the Upper Epiolitic Limestone.*



3. Antinomia angulata. 4. A. angusta. 5. A. dilatata.

Recapitulation.—What I have said regarding the distinctions to be established in the epiolitic formations may be recapitulated as follows:—

1st. The red epiolitic limestones, underlying the cretaceous system of Northern Italy, distinguished by geologists by the general name of *red ammonitic limestone*, belong to the different formations. The first, or oldest, receives a fine polish, and contains many species of *Ammonites* which are never found in the limestone that is above it, although a great quantity of remains of fish are found there, which have their counterparts in the beds belonging to the cretaceous æra; the second, or more recent limestone, is of a schistose structure, is sometimes arenaceous, and contains the remains of fossils, some of which are peculiar to it (*Ammonites, Antinomia*), and some reappear in the neocomian formation; thus showing that they were deposited in a period intermediate between the chalk and the jurassic system.

2nd. The species of the genus *Antinomia*, which we have classified as belonging to all the beds of the neocomian formation (*Antinomia diphya* and *A. deltoidea*), never appear in the underlying epiolitic limestones, in which are found instead other species of the same genus which are peculiar to it (*Antinomia angulata, A. angusta, A. dilatata*).

3rd. The parallelism of the epiolitic limestones and of the cretaceous limestones which cover them is everywhere evident, even when the strata occur in all sorts of directions.

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3. *On the* ORIGIN *of the* MINERAL SPRINGS *of* VICHY. By SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. G.S. L.S., Hon. Mem. R.S. Ed., R.I. Ac., Mem. Imp. Ac. Sc. St. Pet., Corr. Mem. Ac. France, Berlin, Turin, Copenhagen, &c. &c.

IN this memoir I wish to put on record a few observations I made last summer at the baths of Vichy, which may serve to connect the issue of the mineral waters of that place with certain geological phænomena that then fell under my notice.

The little town of Vichy is situated on the right bank of the Allier in the southern portion of the Bourbonnais, and about twenty-five miles south of Moulins. Geologically considered, Vichy is near the northern termination of the great lacustrine formation of the Limagne d'Auvergne, the lower parts of which have been considered to be of older tertiary age. Occupying low hills and plateaux on both banks of the Allier, around Vichy, the lacustrine limestones and marls of that age extend to the north of the Sichon by Cusset as far as Billy (in the direction of Moulins), where they stand out in great horizontal masses to the plains of the Bourbonnais and the Orléanais, without any existing traces of the barrier that formerly retained the waters in which they were accumulated. This fact proves that these deposits are of very remote age as respects the present outline of the country, and leads us to suppose that they have since been raised up *en masse*. The lowest members of this tertiary group are well seen in various sections in different parts of Central France, and consist of granitic arkose, red sandstone, and argillaceous marl, Such strata are not visible in the neighbourhood of Vichy, where the cream-coloured marls and limestone of the Côtes de St. Amand and Cusset are at once in contact with the old slaty schists and porphyries of the Sichon which I have already described*. Organic remains, including the bones of many small quadrupeds, have been found to a great extent, at some localities, in the limestones and marls around Vichy since Sir C. Lyell and myself visited the spot in 1829.

The freshwater limestones are surmounted by beds of pebbles and sand; the former being derived from all the harder rocks which constitute the sides of the great tertiary trough. These pebble and sand beds are of considerable thickness and great breadth, as is well seen in traversing from the eastern side of the great depression near Vichy to its western side beyond Gannat, and particularly in the plateaux of Randans to the south of Vichy. The lowest of the pebble beds rests conformably on the limestone. On the summits and slopes of these central hills is a coarse water-worn drift or shingle, composed

* See p. 13 of this volume.

of various crystalline and schistose rocks, quartz, &c. These are surmounted by finely laminated foxy-coloured sands, and those again by other and finer pebble beds; the last-mentioned being in many places again covered by coarse drift. In the geological map of France the lowest of these pebbly accumulations are represented as younger tertiary. Whatever their relative age may be, they were manifestly all formed under water, which was subjected to great motion, as proved by their water-worn boulders of granite, porphyry, schist, quartz rock, &c. This coarse detrital deposit forms the greatest possible contrast to the minutely aggregated sediment of limestone and marl which had been previously accumulated in a vast interior lake or in several lakes.

And here I would say, that the clearest distinction must be drawn between the above-mentioned ancient detritus of the plateaux and slopes of the hills of the Limagne d'Auvergne, and that which is the produce of the present rivers. In the wide spreading bed of the Allier, which is encumbered with the rocks in question, few or none of the fragments have been derived by that stream from the parent rocks, but have simply been carried into it in floods by the wearing away of banks of the ancient drift, which has been lodged at various elevations, from the lowest depressions, to plateaux 500 or 600 feet above the river beds. I am not aware that any organic remains have been found in this great detrital formation by which its age could be precisely attested.

The mineral waters of Vichy rise along a fissure, parallel to the course of the Allier. This fissure must have traversed a portion of the lacustrine limestones and marls, since that formation rises up into hills on either side of the depression in which the springs occur. The valley is, however, so encumbered with detritus of the overlying and reaggregated pebble beds, that except at the town of Vichy it is almost impossible to make good observations. There, a few rocky mounds rise a little above the Allier, and have served for the site of the ancient "Bourg." In some parts these are undistinguishable from the cream-coloured marls and limestone of the surrounding hills, in others there is indication of their having been accumulated as travertine or tuff, which was formed contemporaneously with the earliest of these tertiary rocks. These beds are horizontal or very slightly undulating, as seen under various buildings, including the great round tower, which overhangs the Allier to the south of the mansion formerly occupied by Madame de Sévigné*. There can be no doubt that these deposits, whether formed by ordinary lacustrine sediment or by the action of mineral sources, are of remote age in relation to our own period; for no springs have issued in the historic time within the ancient town from which they could have been formed.

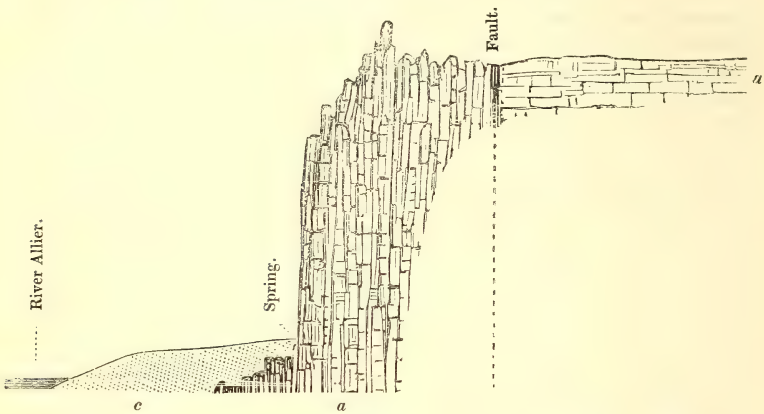
The mineral sources issue, in fact, at lower levels, *i. e.* both to the north and to the south of the rocks on which the old Bourg of Vichy is built. The most southern of these is the celebrated cold spring

* The letters of Madame de Sévigné, vol. v. p. 72 *et seq.*, were written in this house.

which issues from the base of a rock on which the ruins of the ancient convent of the Celestins appears. Having heard from French geologists that this rock was considered to be simply a mass of travertine of comparatively modern date, I was greatly surprised to find exposed in a little pathway, recently cut down on the south side of the cliff, a clear junction of the horizontal strata on which the town is built, with absolutely vertical strata of the same materials, on the tops or edges of which the monks had built their convent. Here, therefore, was a very decisive fault, as represented in fig. 1.

In a sketch of the origin and contents of the waters of Vichy, published in the year 1820*, MM. Berthier and Puvis showed very

Fig. 1.—*Section of the "Rocher des Celestins."*



a. Limestone and travertine of the Celestins in the original horizontal condition.
a', a'. The same, dislocated and vertical.
c. Alluvium of the river-bank.

correctly, that, judging from its composition, this "Rocher des Celestins" must have been the produce of mineral sources. This rock, said they, is so characterized by the fibrous and concretionary structure prevalent in all such tufaceous deposits, and which is indeed apparent in the residuum left by the existing waters of Vichy, where, parting with their carbonic acid gas, they throw down the salts previously held in solution, that doubtless the rock of the Celestins had a similar origin. But much more explanation than this is required to account for the position of the layers of the Rocher des Celestins. The geological description of these authors requires, in short, correction; for no allusion is made by them to the rock being

* "Notice sur les eaux de Vichy," Annales des Mines, 1820, vol. v. p. 413. In the sketch MM. Berthier and Puvis have erred in speaking of granite as the fundamental rock of the district of Vichy. They referred in this case, I presume, to the known relations of the adjacent district of Auvergne, where the tertiary lacustrine deposits rest on granite. Here, however, the crystalline rocks are porphyries and greenstones, which have perforated the adjacent older carboniferous deposits. See *ante*, p. 14 of this volume.

chiefly composed of arragonite; nor do they advert to the abrupt contrast between the absolutely vertical strata of the Celestins, and the horizontal strata of the town with which they come in contact. In their day, in fact, it is to be presumed that the rock was not so freed from superincumbent rubbish as it now is, nor had the junction I describe been laid open.

That the present spring of the Celestins cannot explain the origin of the vertical strata is clear from the fact, that the water rises in very minute quantities at 10 feet below the bottom of the outermost of the vertical layers. In other words, these strata form a cliff about 40 to 50 feet high above the pavement of the well-house (see fig. 1).

On further examination I found these vertical beds ranging on their strike to the S.S.E. for the space of 250 paces, though at a diminishing and very varied altitude, to a spot where they terminate in large slabs 18 to 20 feet high, which stand out like monumental stones, the direction of their faces coinciding with the surfaces of the rocks on which the convent stands. The sketch annexed (fig. 2), which is taken from near this spot, in giving some idea of the scene, indicates a cavity between two of the vertical sets of stone*

Fig. 2.—*Vertical Strata of Limestone and Travertine, as seen in looking towards the Old Convent of the Celestins from the S.S.E.*

a, a'. Vertical travertine rocks.
b. Mass of drift gravel; vertical section seen at *b'*.
c. Flat, occasionally inundated by river-floods.
The position of the fault is marked by the dark vertical cleft.

* In this sketch the spectator is supposed to be standing on the jagged tops of some of the strata (*a'*) near to their S.S.E. end, and to have behind him the

which was probably formed by the wearing away of a substance softer than the other beds. The mass of this rock (about 60 feet wide across the beds) consists of very finely laminated thin-bedded tufaceous limestone of great hardness, of cream and brown colours, and in great part made up of hard translucent arragonite. The thinnest layers are about two inches and the thickest exceed a foot; the former are, however, much the most abundant. Some of the courses of darkish grey layers inclose thin coatings of arragonite, and some of the surfaces are mammillary; particularly where the arragonite has been most elaborated. No one can examine these vertical strata of limestone, tuff, and arragonite, without being convinced that they must have been originally deposited in a more or less horizontal position. If the water which deposited them had cascaded or filtered over a bank-side, it never would have formed a succession of perfectly parallel *vertical* beds, like those now exhibited. In this case, as at St. Alegre and St. Nectaire, in this same region, where great tufaceous deposits are now going on (though of a very different mineral nature from the rock of the Celestins), the tuff thickens out irregularly, according to the downward slope.

Again, it is impossible (independent of the proofs of fracture and dislocation shown in fig. 1) that these vertically-bedded arragonites could have been so deposited after the present geography of the country was fixed and determined; for their summits are higher than any ground in the surrounding locality. Nothing, therefore, short of a jet d'eau, like the Geysers, could have thrown up the waters to deposit materials at such an altitude; whilst no power in nature could arrange falling sediments during their deposit in this *vertical* position along a front of 250 yards. They extend, in fact, much beyond the point where they are exposed in the sketch (fig. 2), and range under the remains of the old convent, now the farm-house there represented.

But independent of such reasoning, I obtained a distinct proof of the comparatively high antiquity of this dislocation, by observing that the rugged and jagged tops of these hard beds, resembling in miniature the peaks and needles of some crystalline mountains, are covered over by coarse gravel, in which granite, porphyry, schist, and other rocks occur, including some fragments of the arragonite itself (see a section of the gravel at *b'*, fig. 2). As this detritus, rising to the height of 50 to 60 feet above the Allier, could never have been placed there in the recent period (where no streams flow), so it is evident that the dislocation, by which the strata of the Celestins were broken off from the contiguous horizontal masses and thrown into their vertical positions, took place at a very remote period. Since that dislocation occurred the tops of the beds have been deeply corrugated, and thus left with outlines wholly dissimilar from those of any strata deposited by a modern spring. The original movements which threw these masses of stone upon their edges in a di-

large isolated flagstones resembling tombstones. The chief mass of the vertical strata is exposed in part in the rocks marked *a*, and is thence continued under the building, or towards Vichy and its line of springs. The spring of the Celestins is on the left.

rection from S.S.E. to N.N.W was also productive of fractures; for separate portions of the mass which deviate slightly from the general and prevalent direction are found to be broken across, and thus the strata here and there dip against or away from each other, all which indicates great violence of movement.

It is important to remark, that the direction in which the vertical strata have been upheaved is also that along which the most remarkable of the mineral springs of Vichy occur. Leaving the well of the Celestins, and passing in the continuation of its line of fracture to the N.N.W. over the masses of calcareous rock and tuff on which Vichy stands, you come to the copious thermal fountain of the Hôpital, whose temperature is 35°·25 Centigrade. Still further to the S.S.E. are the issues of the Grande Grille, 39°·26, and the "Grand bassin," 44°·88; both issuing in different parts of the same great building or "Établissement*."

* It is not my province to enter into details respecting the properties and contents of the various springs of Vichy, which are seven in number; but the four principal sources are those mentioned in the text. The reader who desires to see why Berzelius was of opinion that all such thermal sources were produced by former volcanic action, will consult the 'Quellen von Karlsbad' of that author, who assimilates the origin of those in Germany and elsewhere to that of the numerous "volcanic springs" of Central France. See also Bischoff's 'Vulkanische Mineralquellen Deutschlands und Frankreich,' Bonn, 1826. The order of the strata at Vichy, and the occurrence of granite as the underlying rock whence the springs rise, are inaccurately given by this last author, owing to the work cited by him as authority. (See note, p. 77.) It is interesting, however, to observe, that the springs of Central France which possess the highest temperature are situated in rocks and positions which seem to indicate, that the heat was developed in very ancient fissures; like those of Mont Dor and Chaudes Aigues, the former 45°, the latter 88° Centig. The same may be said of the springs of Gastein in the Alps, whose temperature is 36° Reaumur. I annex a table of the mineral constituents in a gallon of the water taken from the various sources at Vichy. For the medicinal effects of the waters, the reader must consult the publications of MM. Patissier, Petit, &c., and of Dr. Durand Fardel.

MINERAL CONSTITUENTS IN A GALLON OF VICHY WATER.

(Taken from the Rapport sur l'emploi des Eaux Minérales de Vichy, par Patissier et Petit. Paris, Baillière, 1840.)

Substances contained in the waters.	Source of the Grande Grille, temp. 39°·18 C.	Source of the Chomel, 39°·26 Cent.	Source of the Great Basin, 44°·88 Cent.	Source of the Hospital, 35°·25 Cent.	Source of the Acacias, 27°·25 Cent.	Source of the Lucas, 29°·85 Cent.	Source of the Celestins, 19°·75 Cent.
	lit.	lit.	lit.	lit.	lit.	lit.	lit.
Carbonic acid	0·475	0·499	0·534	0·494	0·649	0·540	0·562
	grs.	grs.	grs.	grs.	grs.	grs.	grs.
Carbonate of soda	4·9814	4·9814	4·9814	5·0513	5·0513	5·0863	5·3240
Carbonate of lime	0·3498	0·3488	0·3429	0·5223	0·5668	0·5005	0·6103
Carbonate of magnesia	0·9849	0·0852	0·0869	0·0952	0·0972	0·0970	0·0725
Chloride of sodium	0·5700	0·5700	0·5700	0·5426	0·5426	0·5463	0·5770
Sulphate of soda	0·4725	0·4725	0·4725	0·4208	0·4208	0·3933	0·2754
Oxide of iron	0·0029	0·0031	0·0066	0·0020	0·0170	0·029	0·0059
Silex	0·0736	0·0724	0·0726	0·0472	0·0510	0·0415	0·1131
Total	6·5351	6·5531	6·5171	6·6814	6·7461	6·6678	6·9802

From comparative analyses by Struve it would appear, that the Vichy water con-

If any geologist should observe, upon any one given line, different mineral springs, holding the same salts in solution, as well as impregnated with the same gas, he would naturally infer (particularly if they were hot-springs) that they issued from a deep crack in the subjacent crust of the globe. This presumption is, I think, converted into a certainty in the case of Vichy, by the coincidence of the upcast of the rocks of the Celestins with this line of thermal springs. So far all seems to be a legitimate deduction from facts. But if I am asked, how is it that along the same line of fissure the water of the Celestins, so copiously charged with carbonate of soda and carbonic acid, should be cold, and that the other springs containing those substances are hot? and why the respective temperatures of the warm sources should so vary?—the answers must be hypothetical.

The view of Daubeny and other chemical geologists is that the carbonate of soda, which impregnates mineral waters, is attributable to the action of the carbonic acid they contain upon the felspar of some subjacent rock. In this tract it is very probable that large masses of felspathose rocks (such as the adjacent porphyries of Cusset and the Sichon) lie beneath the tuffs and limestones of Vichy, and really furnish the soda*.

But whatever may be the subterranean source whence the mineral ingredients of these waters may be derived—whether from comparatively moderate depths only in the crust or otherwise, there can be little doubt that their lower or higher temperature is dependent on the aperture beneath each being less or more in connection with a great internal source of heat. Thus, I would infer, that beneath the

tains three times the quantity of carbonate of soda detected in the Carlsbad waters by Berzelius, and nearly twice as much as the most alkaline water of Germany, at Fachingen, analysed by Bischoff. That such a water should have most powerful salutary effects, in many disorders, is not therefore to be wondered at. At the Grande Grille, the ingredients (differing only slightly from the other sources) are as follows:—

Carbonate of soda	21·9058
Carbonate of ammonia	0·0277
Carbonate of strontia	0·0134
Carbonate of lime	0·1441
Carbonate of magnesia	0·2036
Carbonate (proto) of manganese	0·0028
Carbonate (proto) of iron	0·0072
Subphosphate of lime	0·0026
Subphosphate of magnesia	0·0189
Sulphate of potass	1·1760
Sulphate of soda	0·6780
Chloride of sodium	3·3338
Bromide of sodium	0·0007
Iodide of sodium	0·0002
Alumina	0·0049
Silica	0·3696
Solid contents. Total	29·1893

Carbonic acid gas in 100 cubic inches ......97.

Temperature (Fahr.) 107°.

* See Report on Mineral Springs, British Association for the Advancement of Science, 1836, vol. v. p. 20 *et seq.*

Celestins the crack does not open downwards to a depth sufficient to produce a change of temperature, or if ever such deep opening existed, it was probably filled up along a fault. Beneath the waters of the Hôpital, on the contrary, there must still be an aperture adequate to allow a considerable escape of heat; whilst beneath the New Establishment, or farther S.S.W., there is a still deeper and open rent, by which additional gas escapes, and heats the water that has access to it, up to the maximum temperature of nearly 45° Centigrade.

A thermal spring exhibits a constancy from age to age which never has been satisfactorily accounted for, except by supposing that its heat is derived from a great internal and unchanging cause. However we may speculate on this point, the chemist must not forget, that the geologist offers to him the elements to guide his first steps in the inquiry. We show in this case, as in numberless other examples, that the hot water issues from a line of fissure. At Vichy, indeed, we may go farther, and try to explain when the fissure was produced. My impression is, that toward the close of the lacustrine tertiary period (and therefore at a very remote time as respects the present surface) the arragonites and tuffs of the Celestins were formed by very powerful and copious hot springs, and deposited in more or less *horizontal* positions. For, although there are no organic remains to prove that such was their age, all the physical evidences point to that conclusion. I do not doubt that the hard arragonite rocks of the Celestins formed the upper part of the lacustrine old tertiary series of the Limagne, which must have undergone great upheavals *en masse* anterior to the establishment of the present outlines of the land. The best proof of change of position in these limestones is the fact stated in one of the opening paragraphs of this memoir, viz. that there are no barriers whatever on the north by which we can now account for the accumulation of such vast and insulated deposits of terrestrial origin; and that, therefore, the most remarkable changes in physical outline have since been impressed upon the whole region.

The old lacustrine deposits, when formerly insulated by such barriers from the sea, must, indeed, have occupied a considerable depression, which underwent a succession of upheavals, accompanied by the evolution at intervals of much igneous and volcanic rock. In elevations of this extensive and massive nature there must necessarily have been also open cracks, the result of sharp fractures, by which the heat and gas escaped, and one of these was, I presume, the fissure of Vichy, along which some communication with internal heat has ever since been kept up. Now, in Central France (*i. e.* in Auvergne and the Vivarais, or the southern part of this very region) igneous operations have been at work from periods of high antiquity, until the crust assumed nearly all its present outlines, and when volcanos broke forth which poured their lava streams into the existing valleys, as beautifully delineated in the work of Scrope*. I infer that the dislocation at Vichy could not have taken place at this latter

* Volcanos of Central France.

period, because it is manifest, that, since it occurred, there have been considerable changes, in one of which the gravel and debris alluded to were spread over the tops of the broken and eroded strata (see fig. 2, *b*). The fissure at Vichy was therefore probably produced at the period of the emission of the domites, trachytes, and earlier basalts, which, as volcanic outbursts, have little reference to the existing geography of the region. I can now, however, say no more in respect to the earlier volcanic operations of Central France, except to connect them in my mind's eye with the fracture along which the waters of Vichy were first evolved. The full explanation of this subject would require a long memoir, and much more attention than I have paid to the subject. I will conclude, therefore, for the present, with pointing out, that the fracture of the Celestins, and the line on which the thermal waters of Vichy issue, being from S.S.E. to N.N.W., is parallel not only to the depression in which the Allier there flows (probably also a fissure*), but also to the major axis of the Forez, with its old deposits and porphyritic rocks.

* A minor issue of mineral springs, apparently parallel to the fissure at Vichy, occurs on the opposite bank of the Allier.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

July 1*st,* 1850, *to October* 31*st,* 1850.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

AMERICAN Journal of Science. Second Series, vol. x. nos. 28 & 29.

Architect and Building Gazette. Nos. 65–84.

Athenæum Journal, July to October.

Berlin Academy (Royal), Transactions. 1848.

———, Bulletin, from July 1849 to June 1850.

Bordeaux, Société Linnéenne de, Actes. Tome xvi. livr. 1, 2.

Chemical Society, Quarterly Journal. Nos. 10, 11.

Copenhagen, Royal Society, Transactions. Fifth Series. Natural Sciences and Mathematics. Vol. i. 1849.

———, Journal, 1847 and 1848.

Cornwall Polytechnic Society (Royal), 17th Annual Report, 1849.

Edinburgh, Royal Society, Transactions. Vol. xx. part 1.

———, Proceedings. Vol. ii. nos. 35–39.

France, Société Géologique de la, Bulletin. Deux. Série, tome vi. F. 44–47; tome vii. F. 14–30. Liste des Membres, 1850.

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Haarlem, la Société Hollandaise des Sciences. Vol. iii. part 2; vol. v. parts 1 & 2; and vol. vi.

———. Extrait du Programme de la Société, &c., pour l'année 1850.

Horticultural Society, Journal. Vol. v. part 3.

Journal of the Indian Archipelago. Vol. iv. nos. 5–8.

Les Alpes, Journal des Sciences Naturelles, Agricoles, Médicales, Physiques et Astronomiques. Nos. 1–4, 6, 7.

London, Edinburgh, and Dublin Philosophical Magazine. Nos. 246–251. *From R. Taylor, Esq., F.G.S.*

Moscow, Société Impériale des Naturalistes, Bulletin. 1847, nos. 3, 4; 1848, nos. 1–4; 1849, nos. 1–3.

Paris, Académie Royale des Sciences, Comptes Rendus. Tome xxx. nos. 22–30; Tables du tome xxix.; tome xxxi. nos. 1–17; and Tables du tome xxx.

Paris, l'École des Mines, Annales. Quatrième Série, tome xvi. livr. 5, 6; and tome xvii. livr. 1.

Paris, Muséum d'Histoire naturelle, Archives. Tome iv. livr. 4.

Philadelphia, Academy of Natural Sciences, Proceedings. Vol. v. no. 2.

Vienna, Imperial Geological Institute, Jahrbuch, 1850. No. 1.

Zoological Society, Proceedings. Nos. 190–200.

———, Reports of the Council and Auditors, 1850.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Beke, C. T. An Enquiry into M. Antoine D'Abbadie's Journey to Kaffa, to discover the Source of the Nile.

Bellardi, Luigi. Monografia delle Mitre fossili del Piemonte.

Deane, James, M.D. Illustrations of the Fossil Footprints of the Valley of the Connecticut.

Delesse, Achille. Various Mineralogical Memoirs, extracted from the Bulletin of the Geological Society of France, &c.

English, H. The Mining Almanack for 1850.

Favre, A. Notice sur la Géologie de la Vallée du Reposoir en Savoie, etc.

Göppert, Prof. Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterlandische Kultur im Jahre 1848.

Guiet, E. L. Essai de Géologie rationnelle.

Haidinger, W. Naturwissenschaftliche Abhandlungen. Vol. iii.

———. Berichte über die Mittheilungen von Freunden der Naturwissenschaften in Wien. Vols. v. vi. 1849.

Horner, Leonard. Observations on Prof. Lepsius' Discovery of Sculptured Marks on the Rocks in the Nile Valley in Nubia.

Hutton, Captain Thomas. The Chronology of Creation; or Geology and Scripture reconciled.

Jones, T. Rupert. Tunicata.

Jones, T. Rupert. Description of the Entomostraca of the Pleistocene Beds of Newbury, Copford, Clacton, and Grays

Journal of a Tour through the Highlands of Scotland during the Summer of 1829. *From the Author.*

Jukes, J. B. A Sketch of the Physical Structure of Australia.

Karte von dem Kaukasischen Isthmus und von Armenien, von Prof. Dr. Karl Koch. Erläuterungen zu Koch's Karte des Kaukasischen Isthmus und Armeniens. *From the Publisher, Herr V. von Dietrich Reimer.*

Koninck, Dr. L. de. Nouvelle notice sur les Fossiles du Spitzberg.

Lists and Catalogues of Natural History, published by the British Museum, 28 parts. *From Sir Henry Ellis, by direction of the Trustees of the British Museum.*

List of the Fellows and Members of the Royal College of Surgeons. August 31, 1850. *From the Royal College of Surgeons.*

Lubbock, Sir J. W. On the Theory of the Moon. Part 9.

Mantell, G. A., LL.D. A descriptive Catalogue of the Objects of Geology, &c. in the Museum of the Sussex Institution at Brighton, 6th edit.

———. On the Pelorosaurus.

———. Supplementary Observations on the Structure of the Belemnite and Belemnoteuthis.

Memoirs of the Geological Survey of the United Kingdom. Figures and Descriptions illustrative of British Organic Remains. Decades 2, 3. *From the Director General of the Geological Survey.*

Notice sur le Crioceras Voronzovii de Sperk, par G. Fischer de Waldheim. *From the Imperial Society of Naturalists of Moscow.*

Observations made at the Magnetical and Meteorological Observatory at Hobarton. Vol. i. *From Lieut.-Col. Sabine, by direction of the British Government.*

Oldham, Thomas. Presidential Address to the Geological Society of Dublin, Feb. 20, 1850.

On the Gnomonic Projection of the Sphere. *From the Author.*

Prestwich, Joseph, Jun. On the Geological Conditions which determine the relative value of the Water-bearing Strata of the Tertiary and Cretaceous Series.

Reeve, Lovell. Conchologia Iconica. Monographs of the genera Achatinella, Lucina, Artemis, Fissurella, and Partula.

———, and Arthur Adams. The Zoology of the Voyage of H.M.S. Samarang. Mollusca. Part 3.

Report to General Sir T. M. Brisbane, Bt., on the completion of the publication of the Observations made at Makerstoun, by J. A. Brown. *From the Royal Society of Edinburgh.*

Rivière, A. Études Géologiques et Minéralogiques, ou Considérations pour servir à la théorie de la classification rationnelle des terrains.

———. Extrait d'un Mémoire sur les filons métallifères, principalement sur les filons de blende et de galène que renferme le terrain de la Grauwacke de la rive droit du Rhin.

Sedgwick, Adam, A.M. A Discourse on the Studies of the University of Cambridge. 5th edition.

Tchihatchef, P. de. L'Asie Mineure et l'Empire Ottoman, &c.

Wild, John James. A Letter to the Rt. Hon. Lord Brougham and Vaux, containing Proposals for a Scientific Exploration of Egypt and Ethiopia.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

January 8, 1851.

Prof. Heinrich G. Bronn, Prof. Wilhelm Haidinger, Colonel Gregorius Helmersen, and James Dana, Esq., were elected Foreign Members.

The following communications were read:—

1. *On* Tertiary Leaf-Beds *in the* Isle of Mull. By the Duke of Argyll, F.G.S. *With a* Note *on the* Vegetable Remains *from* Ardtun Head. By Prof. E. Forbes, V.P.G.S.

The Island of Mull is deeply indented in a direction nearly east and west by two long arms of the sea, Loch na Kael and Loch Scridden, forming the three natural divisions described by Macculloch as the Northern, the Middle, and the Southern Trap Districts. The Northern division is of comparatively low elevation, and composed chiefly of terraces of trap. I am not aware that it has ever been carefully examined in detail; but it has been understood not to present any features of remarkable geological interest. The middle division is a lofty and rugged tract, containing the fine summits of Ben Tulla and Ben More, the latter being one of the highest mountains on the

Fig. 1.—*Geological Map of Isle of Mull.*

western coast, and visible from a great distance among the Hebrides. These mountains are raised far above the highest level to which the traps of the island attain. A portion of it is coloured by Macculloch as syenite, and specimens in my possession from the Peak of Ben More belong to this class of rock. But the whole of the long and high promontory stretching westward from the flank of Ben More, and lying between Loch na Kael and Loch Scridden, exhibits great terraces of trap, piled one above the other, and terminates in that striking headland of Bourg or Gribon, whose lofty horizontal lines rise from the ocean with almost perfect regularity in a pyramidal form, until the final cap attains an elevation of about 2000 feet.

The southern division has been long known for the magnificent coast scenery it displays; presenting a continuous line of mural precipices of great elevation, frequently based on and capped by basalts of every variety of form, and including extensive strata of the oolite and lias. Sections of this coast have been given by Macculloch * and by Sir R. I. Murchison †.

This division is prolonged considerably farther towards the west than the other two, ending in the long promontory called the Ross. The same geological character, however, is not preserved throughout. At a point nearly opposite to the headland of Bourg, the trap terraces of this division likewise descend, but less abruptly, to a lower level. An interval of mica slate succeeds; and the remainder of the Ross consists of low round hills, entirely composed of a fine hard red granite.

Along the line of junction between the trap and mica slate, the Ross is indented in a direction nearly north and south by a deep bay or arm of the sea, called Loch Laigh. The head of this bay is mica slate, the western side is granite, whilst the eastern is a prolongation of the last and lowest of the trap terraces—the last, I here mean, in the westerly direction, but, as it now appears, the last also probably in respect to age. In most other situations the headland of Ardtun, the termination of this terrace, would have attracted prominent attention; but its basaltic columns, although very perfect and beautiful, are small when compared with those wonderful pillars, which in the same landscape are seen bending round the cave of Staffa, whilst in height it seems an insignificant cliff upon a line of coast marked by the towering precipices of the Inimore of Carsaig and the lofty terraces of Bourg.

The first public mention I can find of the headland of Ardtun is from the pen of Dr. Samuel Johnson. Sir Allan M^cLean, in conveying him from the island of Inch Kenneth to visit the ruins of Iona, selected this spot as a resting-place; and the Doctor mentions that its columnar basalt, on whose broken shafts they sat, was pointed out to him as scarcely less deserving of notice than that of Staffa. This was in 1773, and the visit of Sir Joseph Banks in the previous

* Description of the Western Islands of Scotland, &c. 1819, vol. i. pp. 559, 561; and vol. iii. pl. 20. fig. 11.

† Trans. Geol. Soc., 2nd Series, vol. ii. Pt. 3. p. 359. pl. 35.

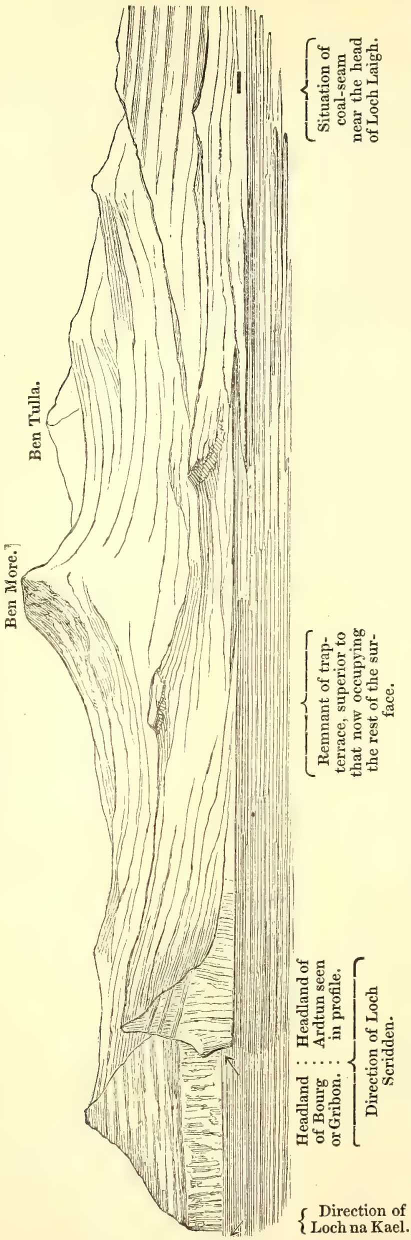


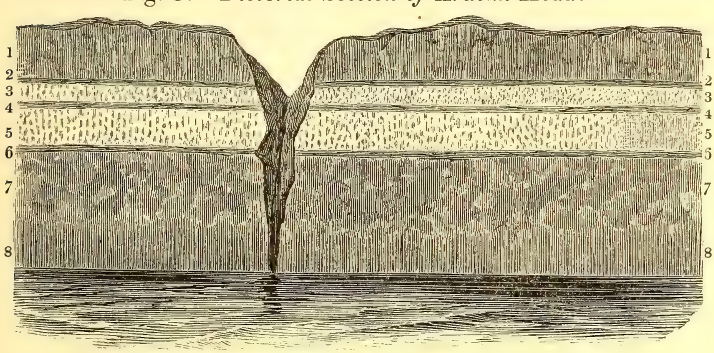
Fig. 2.—*Outline of the Eastern Coast of Loch Laigh.*

year had not yet made fully known to the world the wonders of the cave of Fingal. It is hardly surprising that the remarkable order of the rocks overhead did not attract the particular attention of Sir Allan and his party. But it is more curious that the very spot where that order is best displayed, and where the unusual character of the strata did actually attract minute attention, was visited and examined so long ago as 1790 without any discovery being elicited of the organic remains which have since been brought to light.

In the Philosophical Transactions for the year 1790 (p. 73 *et seq.*) there is a paper entitled "Some account of the Strata and Volcanic appearances in the North of Ireland and Western Islands of Scotland," in two letters from Abraham Mills, Esq. to John Lloyd, Esq., F.R.S. From this paper I have extracted the following account of the headland of Ardtun (p. 78):—"Hence we steered for Ardtun Head . . . . . when we approached the Head, we stopped the rowers and sat some time contemplating the wonderful arrangement of the basaltic columns, and as we rowed along shore to the eastward, had a fine view of the various situations into which the columns are thrown. The coast being everywhere steep, it was some time before we could get a convenient place to land, but having at last got on shore, we marched to the extreme point or head. About a quarter of a mile from this spot is a deep glen, running N.N.E. to the sea. It is about thirty yards in length and twenty in breadth. The strata are disposed in the following extraordinary manner. The uppermost is ten yards of lava with horizontal divisions and vertical joints taking the form of rude pillars. Under this is a horizontal bed of a perfectly vitrified substance, which appears to have been a shale, and is from one to two inches in thickness. Beneath this there is about three yards of a siliceous gravelly concrete, below which are horizontal beds of indurated marl of various thicknesses, from six to twelve inches. The whole of these beds taken together are about four yards . . . . . . Lastly, there are ten yards of rude lava, containing specks of quartz and mica unaltered, pieces apparently of granite, and some nodules of calcined chert. The whole is incumbent on regular basalt pillars of various dimensions from eighteen to six inches in diameter."

With the exception of the total omission of the three beds containing the vegetable remains, two of which, although comparatively thin, are sufficiently conspicuous, this description, as will be seen, is tolerably accurate. Since the visit of this gentleman, I am not aware that this ravine, or "glen," the only point at which the strata are sufficiently accessible to be examined in detail, has been seen or known; the neighbourhood only having been visited at different times by Professor Jameson, the Marquis of Northampton, then Earl of Compton*, and by Murchison and Sedgwick; and although there is some ambiguity in the precise localities alluded to in some of Macculloch's remarks on this district, I think it probable that he had at least coasted round this headland in a boat and observed the lines of stratified matter between the upper and lower basalts.

Fig. 3.—*Pictorial Section of Ardtun Head.*



1, 1. Basalt, rudely columnar.
2, 2. First leaf-bed.
3, 3. First tuff-bed.
4, 4. Second leaf-bed.
5, 5. Second tuff-bed.
6, 6. Third leaf-bed.
7, 7. Amorphous basalt.
8, 8. Columnar basalt.

Although aware that fossil leaves had been accidentally found a few years ago in the promontory of Ardtun, I had not until this year

* See Trans. Geol. Soc. vol. v. Part 2. p. 369.

an opportunity of examining the spot from which they came. Having now had the advantage of doing so in company with James Smith, Esq., of Jordan Hill, I shall proceed to describe the order and nature of the beds presented in the natural transverse section formed by the ravine.

The cliff was roughly estimated, by help of an aneroid barometer, at the height of 130 feet. In the descending order the beds are disposed as follows:—

1. Basalt, accurately described by Mr. Mills as having "horizontal divisions and vertical joints," taking the form of rude pillars. This bed of basalt is thicker on the western than on the eastern side of the ravine, and appears to consist of two sheets, separated by a thin seam of highly vitrified matter or obsidian. Mr. Mills's estimate of the thickness of the basalt may be tolerably correct, viz. 30 feet. The jointed character of this basalt renders it peculiarly liable to the disintegrating effects of weather. The bottom of the ravine is covered with its fallen blocks.

2. The first leaf-bed, a thin seam, about a foot thick, of shaly matter, bearing impressions of leaves and stems of plants.

3. A bed of volcanic ashes or tuff; being an ashy paste full of white angular fragments or lapilli, disposed in a manner characteristic of erupted volcanic matter, and closely resembling, as I am informed by Sir C. Lyell, similar products found in Mont D'Or in Auvergne. It appears to me to resemble very closely also some of the tuffs in those remarkable ravines across which the road passes from Castel a Mare to Sorento, in the vicinity of Naples and Vesuvius; and, further, it was recognised by Mr. Smith, of Jordan Hill, as very similar to some of the volcanic products of the island of Madeira. This bed varies much in the fineness or coarseness of its component fragments; at some points consisting of close fine-grained matter, with white specks more or less abundantly interspersed; at others presenting an exceedingly coarse texture, the paste containing large fragments of a pumiceous matter, with the white lapilli of corresponding size. But there is one peculiarity of a remarkable character; the whole of the beds, although not far removed from the horizontal, dip slightly towards the S.E. or landward end of the ravine; and upon the dip, this bed of tuff passes into a conglomerate of flints, cohering by a cement so tenacious, that the flints themselves frequently break rather than quit their matrix. These flints present, when wet and freshly broken, the most brilliant tints of red and orange, and are evidently more or less in a burnt condition. Some of them, however, are less altered than the rest in texture and colour. One specimen I obtained from external appearance alone was easily identified as an unequivocal chalk flint; and after I had shown it at the late meeting of the British Association, a fossilized organism was discovered in it, which placed this conclusion beyond a doubt. The white lapilli, throughout the whole course of the bed, are generally siliceous; although some of the minuter particles have the appearance of unaltered chalk.

4. The fourth band in the descending order is the second leaf-bed; that which is by far the richest in vegetable remains. It is about

2 feet thick; and the lower portion of it is not so much mineral matter with organic impressions as a compressed mass of leaves, not a few of which, when the layers are partly divided, seem still to retain the damp obscure colours of vegetable decay. The composition of the bed becomes harder, as it passes upward, where there is more and more mineral matter, with fewer impressions of plants. These are still, however, frequent, preserving in large and small leaves the most delicate tracery of the skeleton. Some few impressions of twigs are found even above the limits of the bed, and here and there mark the lower portions of the superincumbent tuff.

5. The fifth bed is a second band of tuff, similar in composition to the one above described, but somewhat thicker. Owing, however, to its dipping under the sloping base of the ravine, less of its course is visible than of the one above.

6. The sixth bed is a seam of what may be best described as baked clay or very fine mud. It is very brittle, but without any particular form of fracture. From its general appearance and relative position among the beds, it at once suggests itself to be a third leaf-bed. Accordingly, after some search, a few impressions were obtained of leaves apparently similar in character to those found in the superior deposits. But the nature of the material prevents more than mere fragments being obtained.

7. Below this third and last leaf-bed the cliff is composed of a dark amorphous basalt. Like most of the traps and basalts of the district, it is of an amygdaloidal structure, the cavities being filled with various mineral crystals. On the surfaces exposed to the action of the air and sea-spray these have decayed out, and the empty holes give here and there a honey-combed appearance to the rock.

8. Lastly, the cliff ends in beautifully columnar basalt, dipping into the sea. I have not ascertained the soundings nor the nature of the bottom, and consequently am unable to say what may be the height of the columns. They may be seen, however, to a considerable depth in the clear waters of that sea. They are sometimes perpendicular, sometimes bent in various directions; a common disposition here being, as at Staffa, a gentle outward curve, as if bending under the weight of the superincumbent cliff*.

The point, at which the ravine exhibits a section of these beds, is that at which the headland reaches its highest elevation. To the W. and E. it declines in height; but the beds containing the vegetable impressions can be traced for a considerable distance along the sea-face; and excellent specimens have been obtained from the second leaf-bed about 100 yards farther to the E. It has been mentioned that the beds dip gently towards the S.; that is, in a direction nearly parallel to the line of Loch Laigh. The surface of the headland of Ardtun follows the same slope; so that at the head of Loch Laigh—that is, in the course of about a mile along the line of dip—the land is but slightly elevated above the level of the sea, and it is remarkable, that at both sides of this headland—upon the shore of Loch Scridden and that of Loch Laigh—a seam of coal has been found

* Since writing the above, I have received from Mr. M'Quarrie a measurement

immediately under a sheet of basalt (see Map, p. 90, and Fig. 2). On the Loch Scridden side this basalt is regularly columnar, some 20 feet high; on the Loch Laigh side it is much thinner, and somewhat resembles a rotten trap. It is impossible not to conjecture from the line of dip of the Ardtun strata, that this coal-seam is a prolongation of one or other of its leaf-beds; and, if so, it would be an interesting instance of the passage of vegetable matter from one condition to another;—from a state, in which it is so slightly altered that every fibre of its original structure remains, to one, in which it is converted into the highly altered mineral, coal.

To return to the strata exhibited at Ardtun. The geological epoch, to which all the beds above that of the amorphous basalt belong, is determined by the character of the organic remains. The leaves are of considerable variety, but all belonging to well-known existing families of the Dicotyledonous order. They are therefore remains of the tertiary period;—a conclusion farther confirmed by the position of the chalk flints in the tuff conglomerates with which they are associated.

Further, these beds seem to me to furnish indisputable evidence of subaërial volcanic action, alternating with periods of repose. The second leaf-bed is the one which throws the clearest light on the circumstances of its formation. It is to be observed, in the first place, that the leaves are not torn or shattered; those of the large palmated planes, as well as those of the small buckthorn, &c., being fully extended, and showing unruffled surfaces. Leaves, violently cast from the trees on which they grew, would not have presented such appearances. They do not even consist with the brittleness of dead leaves, when dry. Two other remarkable circumstances remain to be noticed; first, that no trunks of trees, no branches, nothing beyond

of the various beds at Ardtun. At a point east of the ravine where the lower basalts are more easily measured, the whole series stands thus:—

	Feet.
Uppermost basalt	40
First leaf-bed	2
First ash-bed	20
Second leaf-bed	2½
Second ash-bed	7
Third leaf-bed	1½
Amorphous basalt	48
Columnar basalt to the level of low tide..	10
Total......	131

At the ravine the measurement of the upper series of beds varies considerably from those figures:—

	Feet.
Uppermost basalt	16
First leaf-bed	2
First ash-bed	8
Second leaf-bed	2½
Second ash-bed	6
Third leaf-bed	1½

From this it will be seen that whilst the leaf-beds preserve a remarkable uniformity of thickness, the associated ash-beds and basalts vary much. In the uppermost ash-bed there is a difference of 12 feet, and this within a short distance.

the size of the merest twig, has been yet found associated with the leaves; secondly, that plants of a reedy texture—some of them at once recognisable as *Equiseta*—are associated in great abundance with the leaves, especially with that lower portion of the bed which almost exclusively consists of the vegetable remains. From all this the conclusion is obvious, that these leaves must have been shed, autumn after autumn, into the smooth still waters of some shallow lake, on whose muddy bottom they were accumulated, one above the other, fully expanded and at perfect rest. It cannot have been a water agitated by tides or currents; for these would have swept such remains away, or left evidence in their disposition of disturbing agency. It cannot have been water of any depth; for it is well known that reeds, and especially the *Equisetum* and other kindred families, do not affect such situations. But there is another ground for this latter conclusion: the bed of ashes or tuff covering the leaves shows clearly, from the arrangement of its materials, that they cannot have undergone the sifting process inseparable from subsidence through water. The light pumiceous particles and the heavy flinty white lapilli, are disseminated indiscriminately without any reference to the order of gravity, although the former are composed of a substance which will frequently float in water, whilst the latter are particularly dense and heavy.

All these circumstances taken together, as also the absence of any freshwater shells, or other organisms, indicative of a permanent lacustrine condition, seem to me to afford the strongest evidence, that the situation in which these leaves were overflowed by volcanic mud and ashes, was one, which may rather be described as a marshy terrestrial surface, than the bottom of a lake, properly so called. If this conclusion be correct, it follows that the materials which overlie the leaves were emitted by a volcano in subaërial action. The condition of this matter at the time of its eruption seems pretty clearly indicated by its condition now. First, the damp and bedded leaves have had poured upon them a stream of liquid mud, insinuating itself between their planes, lifting and holding those most easily detached from the surface, and leaving in its original state of rest the lower portion of the bed. To this matter,—which although now appearing in its upper portion as a hard blue stone, bears in the perfect state of its vegetable impressions indisputable evidence of its once liquid condition,—has succeeded an overflow or a shower of matter of very different composition. In respect to the latter, it is more difficult to conclude with certainty what was the original condition. It seems to have followed the mud after a very short interval of time, although long enough to have allowed a partial consolidation. That stray twigs and leaf-stalks were still sticking out of the surface of the mud, is sufficiently proved by their traces, generally much carbonized, in the lower part of the tuff. The line of junction between the bottom of the tuff and the top of the leaf-bed is, in a general view, sharp and definite enough; whilst a closer inspection shows just enough subsidence of the particles of ashes into the substance of the stone below, to indicate the degree of consolidation to which the latter had attained.

These appearances, however, are hardly sufficient to determine whether the tuff was erupted in the form of a muddy flood, or in that of a volcanic shower. A fall of any height through air would, to a certain extent, have the same effect as subsidence through water, in producing an arrangement of particles, determined by their specific gravity. Subsequent heavy falls of rain, however, such as have frequently been known to accompany similar eruptions in the present epoch, by washing down the finer particles, might considerably modify the original conditions. It must be remembered, however, that in the disposition of matter erupted by a volcano, much must depend on the degree of proximity to the seat of action. The nearer that point is, the more completely will the laws of gravity be liable to be counteracted by more violent temporary forces. Now, I think there is some evidence, that the seat of action was at no great distance from the spot described. The tuff-bed is traceable for some distance along the coast; and at one point, the farthest at which I have examined it, the composition is fine-grained and homogeneous, indicating that at the spot referred to, the eruption had undergone a change similar to that which distinguished the fine white ashes which covered the country at Misenum, from the coarser and mixed materials which overwhelmed Pompeii. I have already described also the remarkable change which takes place in the composition of the bed within a few feet of space at the Ardtun ravine. So rapid a transition in character, from a conglomerate of coarse and heavy materials to one of much finer composition, seems to indicate a corresponding rapid change in the intensity of the forces to which the bed owes its origin. The condition of the flints tends to prove the agency of heat; whilst it equally proves that the degree of intensity to which they were exposed was very variable. Some of them have the appearance of having been much burnt, although I observed none in a state of vitrification; whilst others are so little altered as to preserve in good form minute organic remains. From these circumstances, although on this point sufficient data are still wanting, I should be inclined to conclude that the flints had not been thrown out in a fiery shower, but rather having been subjected to considerable heat, modified by the earthy matter with which they were associated, were poured forth with it in a mud-stream. But, whatever may have been the particular process by which the tuff-beds, and this one especially, may have been formed, it is certain that it must have been repeated after a considerable interval of time, and that the volcanic eruption was not of such violence as to change materially the conditions of the surface. The hollow in which the marsh had originally been formed, and in which the first or lowest leaf-bed had accumulated, continued to be a hollow after the mud and ashes had overflowed it. Water again accumulated, and autumnal leaves were again cast upon its surface in greater numbers and variety than before. An eruption similar to the first for a second time covered its deposits; still its condition remained sufficiently unchanged to admit a repetition of the same process, and once more it continued to receive the annual sheddings of a forest vegetation. But the third eruption must have been one of a very different kind; sheets of lava of great solidity and thickness were now poured forth upon the ground, and if surfaces completely vitrified, such as well-marked obsidian, be any indication of subaërial exposure, such must have been the condition of this lava. The configuration of the country no longer remained the same, and so complete was the change effected by this and subsequent convulsions, that the spot which had so long been the receptacle of calm stagnant waters under the lee of some great forest, became as we now see it, cut into the sea-cliff of a naked headland, so peculiarly exposed to the surf of a stormy ocean, as well to deserve the description of its Gaelic name, "the Point of Waves."

It is true, that no evidence remains in the form of visible craters to mark the site of volcanos to which the traps of the Hebrides may owe their origin, and to prove their subaërial character. Such indeed may not have been the character of all of them during the immense periods of time in which their activities were exerted. But in the particular case of the beds here described, with other evidences so strongly marked, I cannot feel that the absence of this particular proof stands much in the way. Of nothing, perhaps, does the whole geology of the Hebrides present more conclusive demonstration than of the enormous changes in the relative position of sea and land, which have been effected since the latest period of volcanic activity of which any evidence remains to us. The position of the leaf-beds in the cliffs of Ardtun is one example. A great portion of the later tertiary period, as well as the whole of that period of submergence to which the Drift is referable, lie between existing times and that to which the sealing up of these beds may be referred. The Ross of Mull, like all the rest of Scotland, presents banks of sea-worn gravel far above the level of the highest Ardtun basalt, and its rocks and boulders are deeply marked by those remarkable abrasions, which, whatever be the particular material which caused them, are apparently due to the action of something impelled by powerful currents. There is some evidence, that the sheet of basalt which caps the Ardtun beds was by no means the last or highest which once occupied the same area. From out of the mosses, now covering its surface, tablets of similar material are seen elevated here and there, with broken joints strewn about at the foot of their little escarpments. They have all the appearance of having formed part of a sheet which overlay the other, and of which these isolated portions are the only remnants (see Fig, 2, p. 92). Unless therefore the original craters of eruption had been above the highest level accessible to such changes, it is not surprising that no vestige should remain of cones of scoriæ, or other accumulations of loose materials. Nor, when they had been once given up to the sea, could we reasonably expect much evidence of this former existence. The ocean cannot often be successfully called to account for such acquisitions; it is, however, a curious fact, that on the shore of the island of Tyree, opposite the basalts of Mull, at no great distance above the reach of the present tides, balls of pumice have been found in considerable abundance. These are of course seaborne, and, although there is no proof of their having been Hebridean products, it may be at least safely asserted that this is as probable an origin as any other.

We may safely conclude that the spot where the leaves are now found, could not have been at any very great distance from at least the border of the forest which yielded them. But it is probable that the country on which it stood has foundered among the subsequent convulsions, which seem to have broken and disjoined so many tracts, once continuous. We may possibly even have a doubtful guess of the direction in which that country lay. The headland of Ardtun does not seem to bear any close relation to the rest of the traps, in the same (southern) district of Mull. At a very short distance to the east upon the southern shore, the terraces of trap are associated, so far as yet examined, with no other formations than those of the oolite and lias. From Macculloch's description, they both underlie and overlie various members of those formations, in a manner very similar to that in which the traps of Skye and many of the smaller islands are found associated with the same series of rocks. The recent observations of Prof. E. Forbes show, that in the case of Skye, this association takes place in a manner which indicates with singular precision the age of some at least of the basaltic sheets (see page 108). I do not believe that the higher basalts of the great precipices of the south coast of Mull ever have been, or perhaps ever can be, examined with very great minuteness. But no evidence certainly exists that any of them are of later date than the secondary period; whilst the great difference of elevation renders it improbable that any of them can belong to the same epoch with the Ardtun beds. I think the only indications of relation in the latter to any of the surrounding formations, point in the northerly direction. No one who has followed the description of the Ardtun Head, and is acquainted with Staffa, will fail to recognise a remarkably corresponding feature. The lowest two members of the Ardtun series—the massive amorphous basalt, passing into and resting upon the columnar,—offer a precise representation on a smaller scale of that wonderful front which lies opposite at some five or six miles' distance. It is to be observed too, that the greater elevation to which these two formations rise in Staffa, corresponds with the line of dip (rising to the north) of the same beds of Ardtun. The whole group of the Treshnish Islands, "which guard famed Staffa round," would seem from their low tabular appearance to belong to the same prolonged sheets of trap, and may represent the skeleton of that country now destroyed, from whose forests the Ardtun leaves were shed. I think it not improbable that by future researches among the conglomerates and other stratified matters associated with the traps in Mull and the neighbouring islands, portions of the more substantial parts of those forests will yet be found. It appears from Dr. Macculloch's account of the traps of the middle district of the island of Mull, that he did actually find the carbonized stem of a tree*, whose structure proved it to be coniferous. His notice of the "vein" in which it occurred is an accurate description of the tuff which covers the leaves at Ardtun; but he expressly says

* *Loc. cit.* vol. i. p. 568, and vol. iii. pl. 21.

that it occupied a *perpendicular* instead of a *horizontal* position in the cliff, and the headland of Bourg seems to be indicated, although not very clearly, as the locality. Mr. M'Quarrie, of Bunessen, to whose intelligent interest I owe many of the best specimens obtained from the leaf-beds, reports to me that he has coasted round the headland of Bourg, and could see no such vein of tuff as that described by Dr. Macculloch.

There is one very remarkable circumstance which may serve, if not to confirm, at least to strengthen the conjecture which would connect the lower basalts of Ardtun with those of Staffa. So far as I am aware, there is only one sheet of trap in the British Islands which can be identified in point of geological age with the *uppermost* basalt of Ardtun. That one sheet of trap is on the coast of Antrim, and it bears to the columnar basalts of the Giant's Causeway the same relation which I have supposed between the corresponding Ardtun bed and the basalts of Staffa. I am indebted to the kindness of James Nasmyth, Esq., of Manchester, for a minute description and relative sketches of the order of the strata in that part of the coast of Antrim, and for excellent specimens of the bed of charred wood, which, as it will be seen, there occupies a position similar to that of the leaf-beds of Ardtun.

1. The first bed (counting, as before, downwards from the surface) is 50 feet of basalt; the upper part being of small, the lower of larger and rude columnar form.

2. A bed of charcoal and lignite. Some specimens show the fibres of the wood as perfectly as if taken fresh from a charcoal kiln. The wood is dicotyledonous.

3. Immediately under the bed of lignite succeeds a great mass of amorphous basalt, precisely as in the case of the Ardtun leaf-beds.

4. Again as at Ardtun, the mass of amorphous basalt rests upon a bed remarkable for the very perfect regularity of its columnar form.

5. A band of matter highly coloured with red oxide of iron succeeds, maintaining its position with great regularity along a great part of the coast.

6. Another bed of amorphous basalt.

7. Another of rude columnar basalt, of a starch-like wavy form.

8. A thin band of red oxide of iron.

9. A very black amorphous basalt.

10. Chalk, on which, dipping into the sea, the whole series of the basaltic beds rest.

From the top of the cliff to the chalk, these beds are no less than 460 feet in height.

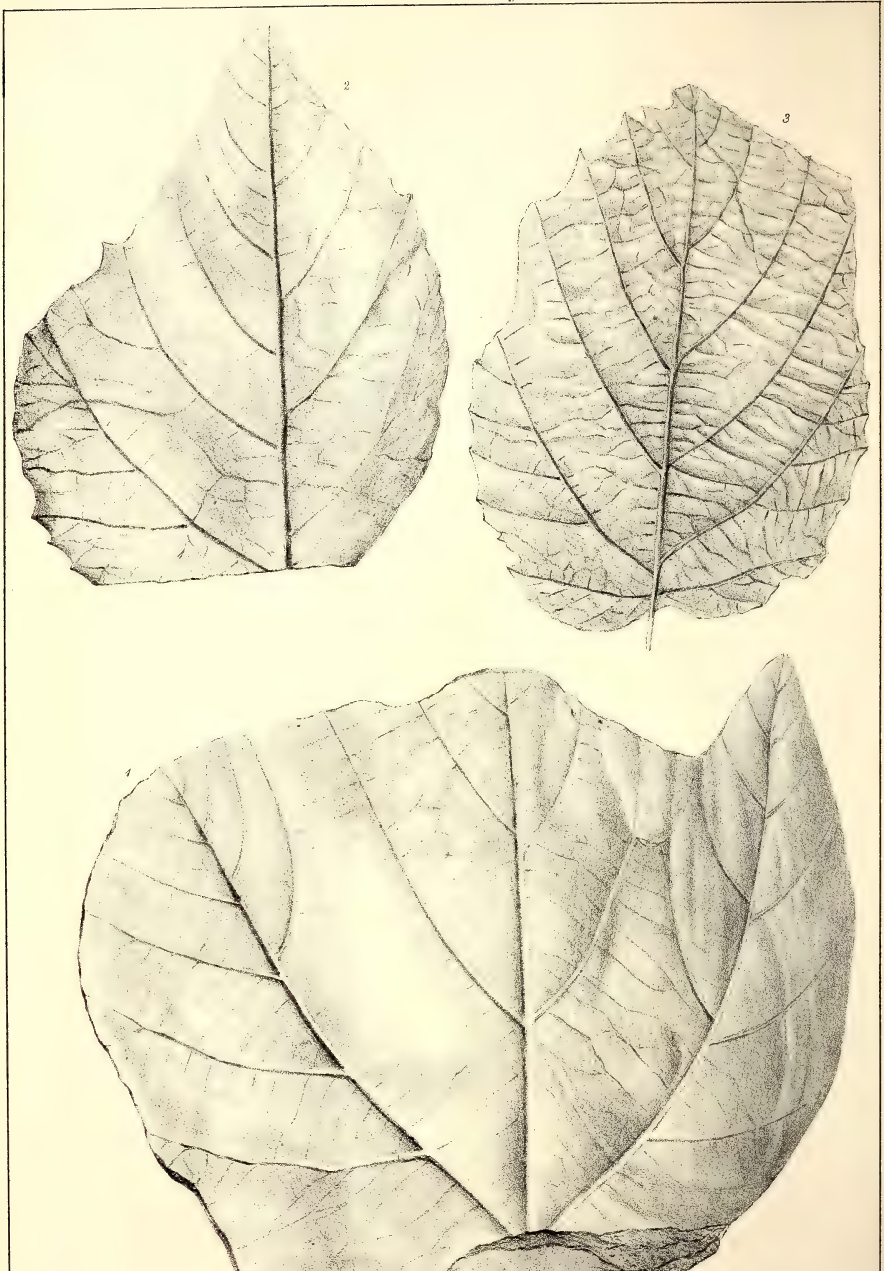
The amorphous and columnar basalts on which the Mull leaf-beds rest may possibly not belong to the same epoch with the closely similar Antrim beds; because we have no positive proof that, like the latter, they either rest upon, or have burst through chalk. The flints of that formation which are found above them may be the debris of chalk, originally deposited in the same position and subsequently washed away; or they may have been rolled by currents from a distance and thrown by volcanic agency on the top of basalts belonging to a former epoch. But I think the most probable conjecture is that, if these basalts do not even now rest upon chalk, they have burst through it, and belong to the same period as the corresponding beds of the Antrim coast. At all events it is clear that the tertiary volcanos which at Ardtun give such clear evidence of intermittent action, have been in a state of still more tremendous activity on the neighbouring coast; and were powerful enough to produce repeated sheets of basalt of a thickness greater than, and of a form very similar to, those on which the leaf-beds rest.

It will be very singular if the comparatively thin sheet of basalt which overlies those beds is the only one in the Hebrides which can be proved to belong to the same period. It would in this case occupy a position of very remarkable isolation; the nearest basalts of the same period being at a distance of not less than 75 miles, with intervening islands, which do not exhibit any development of the trap formation. It is however but a new proof in support of a geological conclusion of much interest, viz. that the basalts of the Hebrides, as we now see them, are the accumulated results of plutonic and volcanic action going on from time to time during an indefinite series of ages,—and frequently not only at immensely distant points of time, but also within very limited areas.

Dr. Macculloch intimates, that he could observe very little correspondence between the beds of trap, even in islands very near each other, although a large number of them over all the islands from Skye to Mull, seem to be referable to periods included in the oolitic and the liassic epochs. Not unfrequently it has been observed by the same writer, that many successive beds of trap rest upon, and include conglomerates consisting chiefly of water-worn remains of the same material; thus indicating that some of the intervals had been long enough to witness vast physical changes—the submergence, destruction, and reaggregation under water of still older rocks of the same formation.

I have very lately had occasion to observe on the coast of Kintyre columnar basalt, which seems to have risen through the old red sandstone whilst the latter was yet in the state of sand, each column being separated from the next on all its facets by cakes of sandstone, now highly crystallized and very brittle; but which, when in a state to follow such labyrinthian lines, must have been soft and plastic.

Before concluding this paper, I may mention that my attention has been drawn by Prof. Nicol to a post-tertiary leaf-bed in Kintyre, which has been discovered in cutting an outfall drain through the flat area called the Laggan. In respect to the manner of deposit, this bed presents a remarkable identity of character with the leaf-beds of Ardtun. It consists of a mass of leaves, fully expanded and mixed with very little mineral matter, associated with reedy plants; the whole still preserving the colours of damp leaves, and, although very rotten, much of their original texture. They have evidently been collected in the same manner—in a shallow marsh, and are



W. H. Baily.

FOSSIL LEAVES FROM ARDTUN HEAD.

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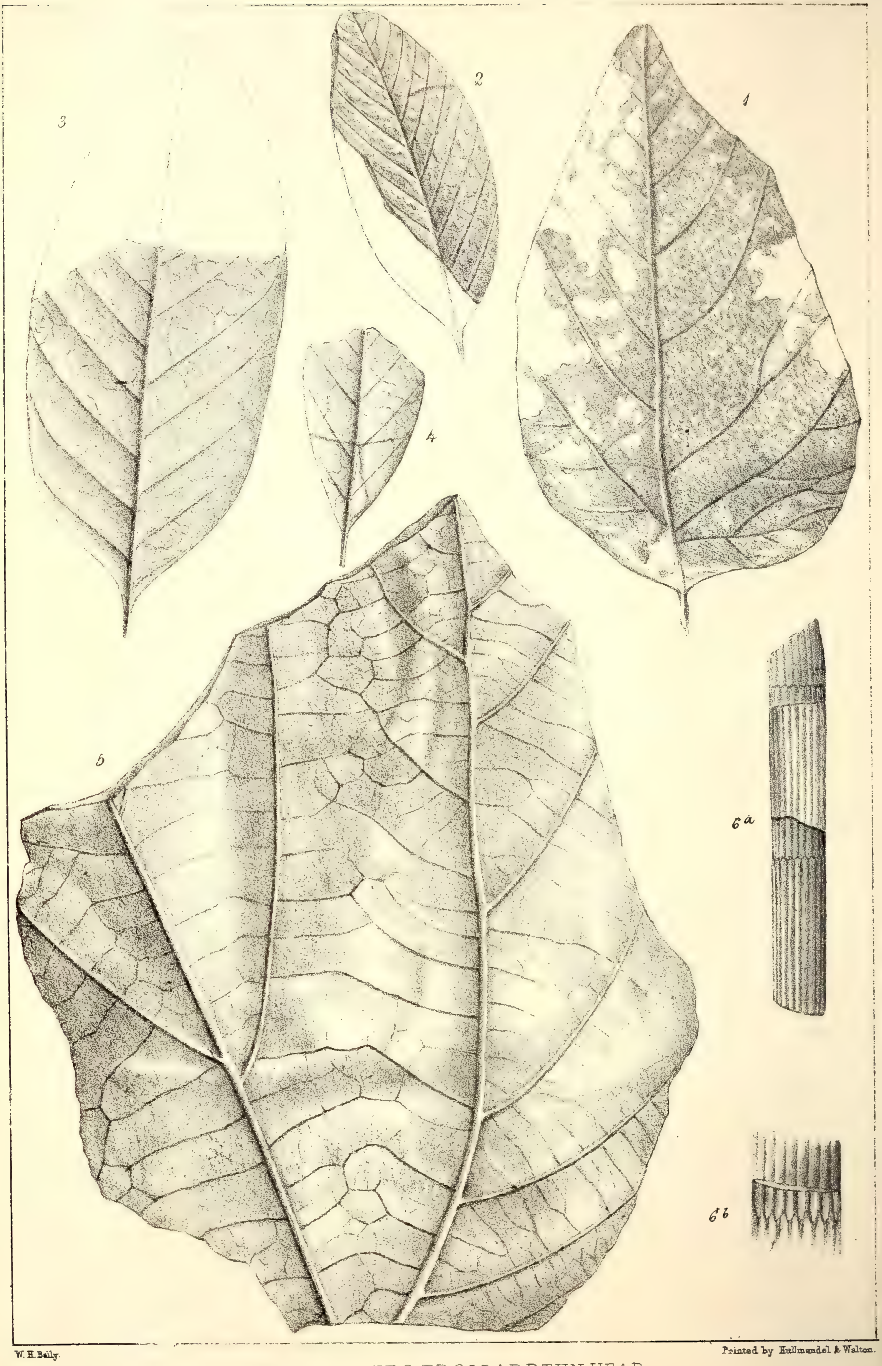

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covered by a bed of clay full of vegetable fibre, which forms the surface of the ground. The leaves however, which when still wet can be lifted from each other quite perfect, belong to a very different age from those at Ardtun; being apparently all of such plants as now grow in marshy situations in the West Highlands,—bog myrtle, willows, alders, &c. The Ardtun leaves belong to species and even families which have long ceased to be indigenous in that country, and indicate the occurrence of changes since the period of their growth, not less great in climate than in the geographical forms of land and sea.

NOTE *on the* FOSSIL LEAVES *represented in* PLATES II. III. AND IV. By Prof. E. FORBES, F.R.S., V.P.G.S. &c.

From among the numerous vegetable remains contained in the Ardtun beds, a few of the most perfect impressions of plants, mostly of leaves only, have been selected for illustration. In accordance with custom, specific names are assigned to these provisionally, for the sake of distinguishing between the kinds found, and of comparing them with fossils of a similar kind found elsewhere. Without much more data than such impressions, however perfect, afford, anything like a specific diagnosis, satisfactory to a botanist, could not be constructed. The general assemblage of leaves when judged by the present state of our knowledge of the vegetation of ancient epochs is decidedly tertiary, and most probably of that stage of tertiary termed Miocene. Their climatal aspect is more mid-European than that of our eocene flora. There is a striking resemblance between many of them and fossils from Styria and Croatia; but so far as I have had opportunities of comparing either with specimens or good figures, the Mull fossils are in all probability distinct from any recorded species. I cannot identify any of them with British eocene forms.

PLATE II. fig. 1*a*, 1*b*. *Taxites*? *Campbellii*. Fragments of a coniferous tree, possibly a *Taxus*; allied to the *Taxites Rosthorni* of Unger, from the miocene lignite of Carinthia.

PLATE II. fig. 2*a*, 2*b*. Part of a frond, probably that of a fern, but presenting some anomalous features which future specimens will probably explain. For the present it may be called *Filicites*? *hebridicus*.

PLATE III. fig. 1. An inequilateral leaf, the affinities of which are doubtful.

Fig. 2. *Rhamnites*? *multinervatus*.

Fig. 3. *Rhamnites*? *major*.

Fig. 4. *Rhamnites*?? *lanceolatus*.

Fig. 5. *Platanites hebridicus*, var.?

Fig. 6*a*, 6*b*. *Equisetum Campbellii*.

PLATE IV. fig. 1. *Platanites hebridicus*. This leaf is one of the most abundant and characteristic of all those found at Ardtun. It has a close affinity with the *Platanus hercules* (Unger, Chlor. protog. p. 138. t. 46) from the marly slates (said to be eocene) of Croatia.

Fig. 2. Affinities doubtful.

Fig. 3. *Alnites*? *MacQuarrii*.

2. *On the* Estuary Beds *and the* Oxford Clay *at* Loch Staffin, *in* Skye. By Professor Edward Forbes, F.R.S., V.P.G.S. &c.

The purpose of the following brief notice is to put on record some observations made in the island of Skye in August 1850, by which the true geological horizon of the so-called "Wealden" of Loch Staffin was determined, and the Oxford Clay added to the series of oolitic strata in the Hebrides.

Sir Roderick Murchison, in his "Supplementary Remarks on the Strata of the Oolitic Series and the Rocks associated with them in the Counties of Sutherland and Ross, and in the Hebrides," read before the Geological Society in November 1827, states that "in the low and ruinous cliff of blue shale, associated with zeolitic and amygdaloidal trap on the north-eastern shores of Loch Staffin, were found, during my late excursion with Professor Sedgwick, flattened masses of shelly limestone containing five species of *Cyclas*, one *Paludina*, one *Neritina*, one *Ostrea*, one *Mytilus*, and some undescribed bivalves," and remarks that "it adds materially to the interest of these remains, that two species of the *Cyclas*, the *Paludina*, and the *Ostrea* prove to be identical with the fossils of one of the upper beds of the Weald clay described by Dr. Fitton as occurring in Swanage Bay, Dorsetshire, and in the Isle of Wight." Of these fossils a list is appended to the paper, drawn up by Mr. Sowerby; and besides the references to Weald Clay species, one *Cyclas* is considered identical with a Barton Cliff shell, and the *Nerita* is compared with a Woolwich species.

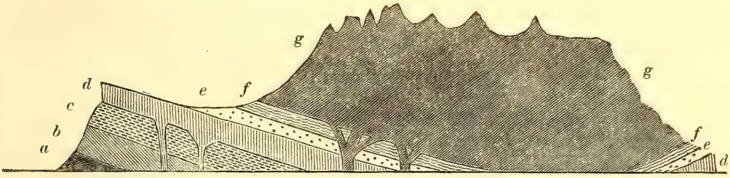
When the Duke of Argyll announced his important discovery of tertiary strata, probably of freshwater origin, associated with traps in the island of Mull, it occurred to me that possibly the Loch Staffin beds might prove to be tertiaries also; the more likely since some of their fossils had been referred to tertiary species. At the same time I felt very anxious to ascertain whether on the other hand they might really be Wealden strata, or what was more probable, as Mr. Robertson had suggested in his interesting paper on Brora, equivalents of the estuary strata associated with the Brora oolitic coal. My recent researches among the Purbecks had led me to distrust all the older determinations and comparisons of freshwater fossils, and I felt that it was of great consequence to the special work in which I was officially engaged in my duties as a member of the Geological Survey, that before publishing the full account of the palæontology of the Purbecks now in course of preparation, I should examine the Loch Staffin fossils, and, if possible, personally inspect their locality. This I felt to be the more necessary, since I had been told by Sir Roderick Murchison that the fossils in question were taken from loose blocks of stone, the exact position of which *in situ* had not been seen.

Many of the Hebridean localities are so out of the way of travelling that it is by no means easy to visit them. Loch Staffin and Loch Laigh (the latter in the neighbourhood of the Duke of Argyll's leaf-beds) were of this kind. But all difficulty was removed by a proposal from my excellent friend Mr. MacAndrew to accompany him on a cruise in his yacht to Mull and Skye, and so examine at our leisure the desired places. Accompanied by Professor Goodsir of Edinburgh, accordingly we set sail, and in the course of three weeks' cruise had not only the good fortune to see the geological points in question, but also to add not a few fossils and nearly twenty species of living animals to the British fauna.

The peninsula of Trotternish, which forms the north-western portion of the island of Skye, presents on its northern line of sea-coast a range of magnificent cliffs, extending from Portree to Loch Staffin. The crest of these cliffs is composed of a vast bed of imperfectly columnar trap, resting on oolitic sandstones, limestones, and shales, the uppermost of which were determined by Sir Roderick Murchison to be the equivalents of the cornbrash and forest marble. Beneath these we find unquestionable representatives of the middle and inferior oolitic strata, and at the base of all undoubted lias. They abound in fossils, and, whenever the palæontology of the secondary rocks of Scotland shall be scientifically explored, will afford a rich harvest of beautiful and probably undescribed forms of invertebrata to the naturalist who may have the good fortune to undertake the work.

Through the oolitic strata are seen rising dykes of greenstone in communication with the spread of trap above, and other trap dykes are seen which not only burst through the greenstone, but also through the sheet of trap forming the perpendicular wall on the summit of the cliffs.

Diagram of the Geological Structure of Trotternish in Skye.



a. Lias.
b. Inferior oolite.
c. Middle oolite.
d. Imperfectly columnar basalt.
e. Estuary shales.
f. Oxford clay.
g. Amygdaloidal trap.

The strata of the cliffs dip rapidly inland southwards at a considerable angle, and a little way behind them towards the east. Farther back towards the west rise lofty hills of amygdaloidal and zeolitic trap, which, broken up into fragments on these escarpments, form magnificent isolated blocks and pinnacles of rock of vast height and slenderness, resembling so many gigantic castles and towering spires of dimensions beyond the workmanship of human architecture. The truly wonderful scenery of the Storr and Quiraing, which far surpasses for irregularity any other rock landscapes in Britain, have been produced by the breaking up of this amygdaloidal escarpment.

The cause of this extraordinary range, extending over many miles, of cyclopean ruins, depends upon the fact which it is my object to announce in this communication. Between the mass of amygdaloidal trap and the columnar trap which crests the sea-cliffs and dips inwards with the underlying oolitic strata, intervene beds of soft shale and crumbly limestone, the wearing away of which causes the breaking up of the superincumbent mass, the retrocession of the main body of trap, and the isolation of the blocks and pinnacles, which probably become more numerous after every winter.

The open bay called Loch Staffin lies at the westernmost extremity of Trotternish. Its northern headland is composed of the oolitic beds and superincumbent columnar trap dipping southwards, and its southern by the same traps rising again to commence a new line of coast, forming the southern bound of the peninsula. The bay itself has been formed in consequence of the wearing away by the waves of the shales above the columnar trap, thus brought into contact with the force of the sea; and as the westernmost extremity of the range of amygdaloidal hills corresponds nearly to the centre of the bay, the ruin of the superincumbent trap is here very great indeed. It was on the shores of this bay that Sir Roderick Murchison and Professor Sedgwick found the blocks of freshwater or estuary limestone referred by them conditionally to the Wealden.

On landing, I found similar blocks with similar fossils, but could not see them *in situ* in the section along the coast. I found, however, very soon that the black shales included in and underlying the amygdaloidal trap were fossiliferous, and before long had the pleasure to find numerous specimens of *Ammonites cordatus* and *Belemnites Owenii* and *Beaumontianus*, indicating the age of these shales beyond a question to be that of the Oxford clay, to which stratum indeed mineralogically they have the most marked resemblance.

When the tide receded, the beds of shale were exposed in regular sequence along the shore, and *beneath* them in conformable succession I found *in situ* the strata of yellowish crumbly limestone and shale with estuary fossils from whence the blocks referred to had been derived.

The series of beds seen in the section in descending order is as follows:—

1. Immediately below the amygdaloidal trap, which is crumbly and wackaceous at the junction, there is a thin band of small rolled pebbles mingled with fragments of jet.
2. Crumbling blue shales with *Belemnites Owenii*, *Ammonites cordatus*, and *A. Eugenii*, about 5 feet in thickness.
3. A thin band of concretionary limestone.
4. Five feet of blue shale with Ammonites and large Belemnites.
5. Two bands of hard grey concretionary limestone, weathering yellow, in which I could find no fossils, 3 feet.
6. Dark blue shales with small Belemnites, 7 feet.
7. Concretionary reddish and yellowish limestone with large Belemnites, 1 foot.
8. Blue shales, 1 foot.
9. Ferruginous sands with fragments of wood, pyritized and in the state of jet, 1 foot.
10. Concretionary limestone with Belemnites, 1 foot.

11. Soft white sands with traces of bivalve shells, apparently *Cyrenæ*, 3 feet.

12. Hard sandstones with *Perna* and numerous *Ostreæ* and *Cyrenæ*, 2 feet.

13. Greyish sands with carbonaceous streaks and lenticular courses of comminuted shells; concretions in places; 5 feet.

14. Hard calcareous shales with bands of *Cyrenæ* and fossil wood, 3 feet.

15. About fourteen bands of loose calcareous slaty and shaly beds filled with *Cyrenæ*, occasional *Uniones*, and *Ostreæ*: these appear to constitute a thickness of about 12 feet, but the base of them resting on the basalt is concealed under water.

The dykes of trap in communication with the superincumbent amygdaloid bake the strata through which they pass and alter the mineral character of the fossils.

The position of these estuary beds, beneath the Oxford clay and above the mass of the middle oolites, at once removes them from identification with Wealden or tertiary strata of the South of England, and as readily suggests a comparison of them with the so-called "Wealden beds," discovered by Mr. Alexander Robertson, intercalated with the carboniferous portion of the oolitic strata of Brora in Sutherlandshire, and described by that gentleman in two most interesting papers communicated to the Geological Society in 1843 and 1846. The main seam of Brora coal lies immediately beneath a stratum containing Kelloways Rock fossils, and regarded by Sir Roderick Murchison as the representative of the pier stone of Scarborough. Below the coal beds are bituminous shales, clays, and a thin layer of whitish argillaceous limestone, containing numerous remains of Fish, and of shells of the genera *Cyclas* or *Cyrena*, *Unio*, *Perna*, *Tellina*, and *Paludina*. These shales are superior to the oolitic and liassic strata.

Mr. Robertson enumerates the many fossils found by him, but does not describe or figure the new species. Of the freshwater or estuary invertebrata found by him in the Brora strata, only two are mentioned as identical with known species, viz. *Cyclas angulata*, identified with a Wealden shell, and *Cypris granulosa*, considered the same as a Wealden crustacean. Mr. Robertson presented the best specimens of all his species to the Geological Society, where I have had an opportunity of inspecting them, and can speak to their distinctness from known forms, or from any of the many Purbeck fossils known to me and not published. Both the identifications above mentioned I consider to be insufficient. The *Cyclas*, called *angulata*, from Brora is not to me identical with Sowerby's shell, and the *Cypris* referred to *granulosa* is altogether distinct.

Through the kindness of Sir Roderick Murchison, I have had an opportunity of comparing his original Loch Staffin fossils with those collected by myself. He procured two with which I did not meet, and I found some additional to his. None of the identifications in the list appended to his paper will now hold. The comparison and determination of freshwater bivalves is a matter of great delicacy and practice; the distinctions between the species of *Cycladidæ* and *Unionidæ* respectively being of so delicate a character that the examination of numerous specimens of each species is necessary, combined with a knowledge of the recent species of these excessively difficult tribes. I cannot satisfy myself that any one of the Loch Staffin shells is identical with a Purbeck or Wealden species. This in the present state of our knowledge was to be expected.

A more curious result is that, after a close comparison of both Sir Roderick's and my own specimens (now contained in the collection of the Museum of Practical Geology), I cannot satisfy myself that, with the exception of the *Paludina conulus* of Robertson, which is a little *Hydrobia* identical with the unfigured *Paludina* mentioned in Sir Roderick Murchison's Loch Staffin list, there is any one of the Loch Staffin estuary shells identical with a Brora species. The little *Hydrobia* above mentioned, however, appears to be undistinguishable.

The succession of events indicated by the section I have described is of no small interest, when considered in its bearing on the physical geography of our area during the oolitic epochs. From the lias up to the cornbrash, or beds probably equivalent to that stage in the series of oolites, we have in the Hebrides, as was indicated by Macculloch and proved by Murchison, a continuous sequence of marine conditions, which, if I might venture to judge from the as yet imperfect evidence of the contained fossils, prevailed in a sea by no means shallow. But at the termination of the deposition of the middle oolitic strata, we have indications of most important changes, and of the conversion of the bed of the Hebridean oolitic sea into an estuarine and terrestrial area, which after a considerable lapse of time became submerged under oceanic conditions and had a new series of marine strata deposited upon it.

If I read what I have seen aright, the plutonic phænomena which accompanied these changes were not less interesting. The great and thick sheet of imperfectly columnar basalt which has so wide an extension in the island of Skye, and plays so important a part in the formation of the magnificent scenery of its coasts, was the product of a submarine eruption, which, if we regard this basalt as an overflow, has its geological date marked to a nicety, having occurred at the close of the middle and at the commencement of the upper oolitic period. This vast cap of compact volcanic matter served to assist in the consolidation of the muddy and sandy marine accumulations over which it spread, and the Titanic throes of this region of eruptions elevated the whole probably above the level of the ocean, and converted a part at least of the sea-bed into dry land, the area of which and of its fresh and brackish waters became again submerged, to be again overwhelmed by the destructive outpourings of submarine volcanos; their results we now see in the great and thick mass of trap forming the line of hills constituting the chain of the Storr. This trap has features distinct from those presented by the bed between the middle and upper oolites. It is in great part an amygdaloid, and its vesicular character may indicate the formation of it at a different depth of water and under different circumstances; a conclusion consistent with the indications presented by the fossiliferous strata which it overlies and alters.

Another view may be taken, however, of the origin of the basaltic sheet intervening between the upper and middle oolites in Skye, one which would seriously affect the preceding estimate of its date. It may be regarded as intruded trap, insinuated between superior and inferior strata at an epoch long posterior to that of the deposition of the former. A minuter investigation of the geological phænomena of the north and west of Skye than has yet been made will probably determine which view is the right one beyond question. But in the present state of the evidence I incline to regard the basalt as contemporaneous with the oolites, and as of the definite date which its position in sequence of beds seems to indicate. The great spread and uniform thickness presented by this sheet of basalt, as far as it has been examined, the unaltered condition of the strata which lie upon it, and the baking of the rocks beneath it and of those which the jets connected with it pass through, are facts which determine me at present to regard it as a bed of the date previously suggested. At the same time, in the Loch Staffin section there are appearances at some of the points where the trap bursts through the superincumbent strata which I could not clearly make out, and which, from their connection with the faulting of the beds, at first sight seemed to indicate disturbances produced by the lower trap. My belief at present is, however, that the disturbances alluded to are results of the jets of amygdaloidal trap distinctly seen bursting through the lower and middle oolites and the basalt, and breaking up and baking the estuary beds and Oxford clay, on which the amygdaloid is overspread in mass.

The area of the Hebrides appears to have been a scene of igneous eruptions and disturbances of level from a very early geological period down to the age of the newer tertiaries. These beautiful and singular islands present a rich field for geological explanation, much as has been done among them. Their palæontology, one of the freshest and fullest mines for discovery yet remaining in the British Islands, may be said to be unexamined. The working out of the exact relations in age of the igneous with the stratified rocks of the Hebrides, and of the physical and vital phænomena determined by the several eruptions within their area will sooner or later be one of the most delightful and best-rewarded tasks to which a competent observer can apply.

List of FOSSILS *collected at* LOCH STAFFIN, *with Descriptions and Figures of the New Species.*

Oxford Clay.

Ammonites cordatus, *Sowerby.*
Ammonites Eugenii, *Raspail.*
Ammonites Vernoni, *Phillips?*, possibly a variety of *A. biplex.*

Ammonites; fragment of a species nearly allied to *A. zignodensis* of Alcide D'Orbigny.
Belemnites Owenii, *Pratt.*
Belemnites Beaumontianus, *D'Orbigny.* This is the *B. sulcatus* of the Brora lists.
Turbo; a muricated species too imperfect for determination.
Nucula; remains of two species.
Pinna mitis, *Phillips*?
Arca concinna (Cucullæa, sp.), *Phillips.*
Avicula; species uncertain.
Gryphæa dilatata, *Sow.*

Staffin Estuary Shales.

Rissoa (Hydrobia) Conulus. *Paludina conulus* of Robertson. Plate V. fig. 12.

Shell very minute, conical; whorls five or six, rounded, smooth, the last very large and much broader than the others, occupying rather less than half the length of the shell. I have compared the specimens with those of "*Paludina conulus*" (Robertson MSS.) from Brora, in the Museum of the Geological Society, and can detect no difference. The *Hydrobiæ* are *Rissoæ,* for the most part inhabiting brackish water. The species can be distinguished from each other only with difficulty. This is the unfigured *Paludina* compared with a Weald Clay species in the list appended to Sir Roderick Murchison's paper in vol. ii. p. 366, Geol. Soc. Trans., Second Series.

Neritina Staffinensis. Plate V. fig. 13 *a*, 13 *b*.

"*Nerita* or *Neritina,* not figured, resembling Woolwich shells."—*Geol. Trans. loc. cit.* p. 366.

A minute shell not exceeding three-twelfths of an inch in length, and unfortunately rare and in bad condition. It is smooth, with a body whorl widening and becoming ventricose towards the aperture; the spire is very short, obsolete, and of few and close volutions. Although so imperfect, it is evidently quite distinct from any described *Neritina.* I found only two specimens.

Ostrea Hebridica. Plate V. fig. 4 *a*, 4 *b*, 4 *c*.

Ostrea with the under valve spatulate, rarely short and subtriangular, rather smooth, gently tumid, sometimes highly convex; upper valve flat, or nearly flat. Length of a large example one inch and three-tenths, and breadth eight-twelfths of an inch.

This is the "flat species of *Ostrea*" mentioned in Geol. Trans. *loc. cit.* p. 366, and there identified with one found with *Cyclas media* in the Isle of Wight. Being very familiar with the oysters of the Wealden and Purbeck I cannot admit this identification, nor can I refer the Loch Staffin shell to any known fossil, although, as usual in this variable genus, it is difficult to express in words its marked distinctions. It is abundant, and from its association with *Cyrenæ* appears to have inhabited brackish water.

PERNA MURCHISONII. PLATE V. fig. 1 *a*, 1 *b*, 1 *c*.

Shell elongato-subtriangular, valves unequal but both tumid, anteally straight, very tumid and steep-sided, posteally angulated, rapidly declining to an acute margin, surface obsoletely wrinkled; dorsal portion not expanded, ovate. Hinge-line very oblique, straight, terminating at less than half the length of the shell, beaks acute; young shells dorsally carinated; pits of hinge distant, four or five in number. Length 1 inch $\frac{3}{12}$ths. Maximum breadth $\frac{8}{12}$ths of an inch. Thickness of shell with valves united $\frac{9}{12}$ths of an inch. This well-marked *Perna* differs from any of the species of which I have seen examples from Brora, and is equally distinct, or more so, from that which I have found in the Purbecks. It is the "*Mytilus?*" of Sir Roderick Murchison's list (*loc. cit.*). I have dedicated it to that distinguished geologist, as the discoverer of the Loch Staffin estuary strata.

TRIGONIA TRIPARTITA. PLATE V. fig. 11 *a*, 11 *b*.

Shell moderately tumid, ovato-subtriangular, obliquely carinated, the carina nodulose; the space between the carina and the posteal margin is occupied by about three longitudinal radiating ribs, not very elevated; the central portion of the shell is ornamented with eight or nine very oblique strong rounded ridges proceeding from the nodulations of the keel towards the margin in an anteal direction, but all stopping short except the two lowest, and forming acute angles with a third and more numerous (about twelve) set of acute and slender ribs which run very obliquely in the contrary direction, *i. e.* from the anteal margin towards the centre of the shell. The teeth of the hinge are strong and well marked. The largest valve found measured $\frac{8}{12}$ths of an inch from beak to frontal margin, by $\frac{9}{12}$ths of an inch maximum breadth. The height of a single valve was rather more than $\frac{2}{12}$ths of an inch. I found only single valves of this curious and very distinct *Trigonia*, an ally of *T. undulata*, and characteristically an oolitic form.

UNIO? STAFFINENSIS. PLATE V. fig. 5 *a*, 5 *b*.

I have given this name provisionally to impressions of a bivalve having the form and aspect of a small *Unio*. It is transversely oblong, inequilateral, depressed, truncated anteally, rounded and narrowed posteally, and transversely sulcated. Its breadth is $\frac{5}{12}$ths of an inch. Adult specimens will probably be found hereafter.

CYRENA JAMESONII. PLATE V. fig. 7*a*, 7*b*, and variety, fig. 8*a*, 8*b*.

Shell moderately tumid, ovate, inequilateral, anteally declining, anteal extremity subcentral, posteal rounded but not abbreviated, surface obsoletely furrowed by lines of growth, sometimes nearly smooth, beaks subacute. Length of a fairly grown example (not the largest found) $\frac{8}{12}$ths, breadth 1 inch, and thickness $\frac{5}{12}$ths of an inch. This is an abundant shell. I cannot distinguish specifically between the two forms, the one rather more tumid and narrowed posteally, and the other rather compressed and wider posteally. The latter is the *Cyclas media* of Sir Roderick Murchison's list. After a careful comparison of this *Cyrena* with Mr. Robertson's Brora specimens, and the large series from the Purbeck, Hastings sands, and Wealden, in the Museum of Practical Geology, I feel bound to consider it distinct. It is a characteristic shell of the Staffin beds, and is found in large masses. I have dedicated it to Professor Jameson, a memorial of his many and valuable researches in the Hebrides, and as a token of respect from one, who esteems as a high honour the good fortune of having been a pupil of that eminent geologist.

CYRENA ARATA. PLATE V. fig. 6 *a*, 6 *b*.

Shell much depressed, very inequilateral, posteally abbreviated, ovate-subquadrate, surface regularly sulcated concentrically, ridges acute, numerous, narrower than the interspaces. Breadth $\frac{4}{12}$ths, length $\frac{3}{12}$ths of an inch. This very distinct species is comparatively scarce, and not gregarious.

CYRENA CUNNINGHAMII. PLATE V. fig. 9 *a*, 9 *b*.

Shell depressed, subinequilateral, subquadrate, wide and subtruncated anteally, rounded posteally, anteal extremity just above the frontal margin; surface obsoletely wrinkled by layers of growth; beaks not prominent, rather obtuse.

Length of a large specimen $\frac{9}{12}$ths of an inch, breadth 1 inch; thickness half an inch.

This appears to be distinct from *C. Jamesonii*, and is easily recognised by its small and depressed beaks. I have dedicated it to the memory of my late friend and fellow-student, Mr. Hay Cunningham, whose Memoirs on the Geology of Scotland held out hopes of future discoveries, too soon destroyed by his premature death.

CYRENA MACCULLOCHII. PLATE V. fig. 10 *a*, 10 *b*.

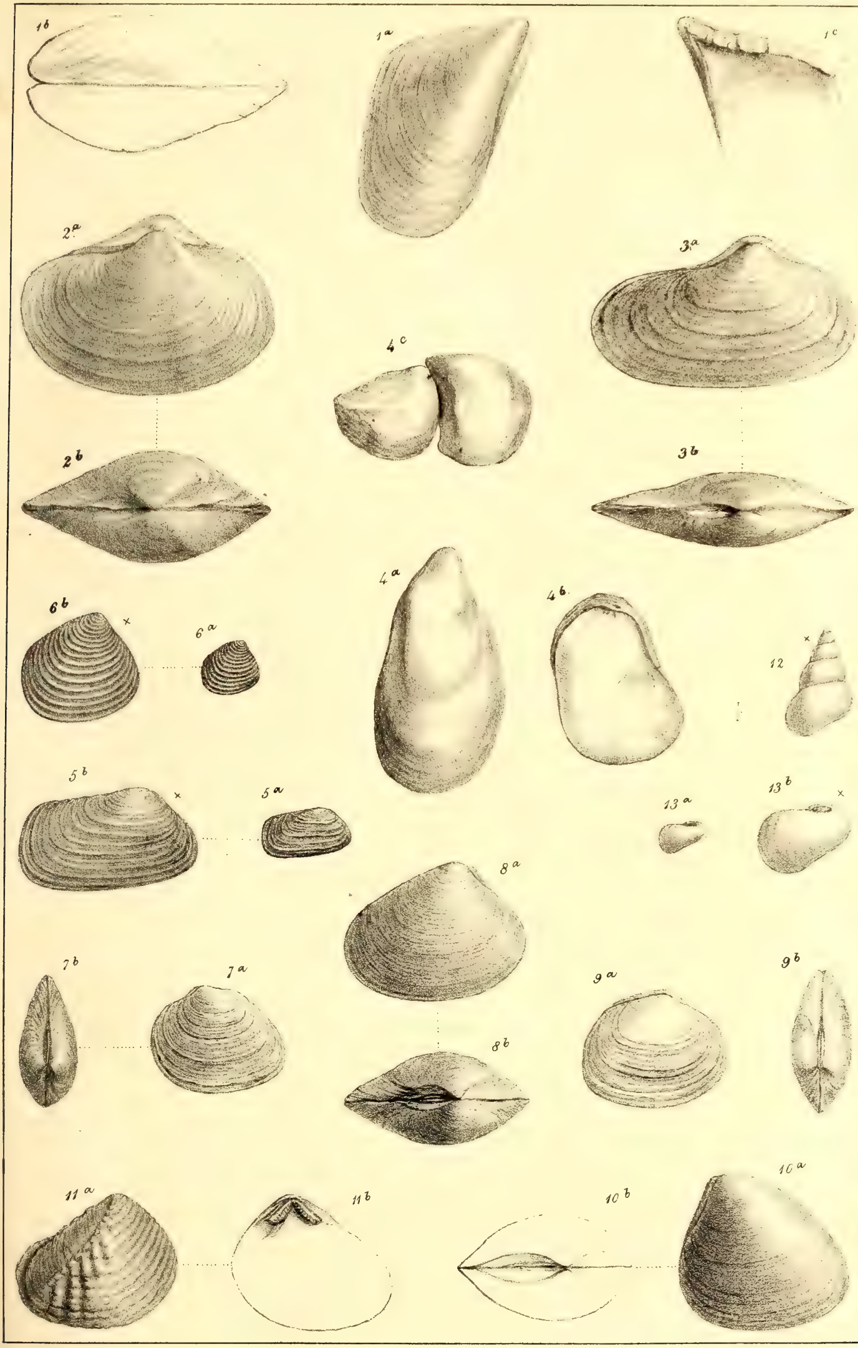
Shell tumid, strong, more or less subtriangular, abbreviated posteally, obliquely subangulated anteally, surface with frequent and close lines of growth, beaks very prominent. Length $\frac{9}{12}$ths, breadth $\frac{10}{12}$ths, thickness $\frac{6}{12}$ths of an inch. This *Cyrena* is constantly associated with the *Perna*. It varies considerably in characters and outline, but appears to be distinct from its congeners, and to occupy a special horizon in this series of estuary beds. I have named it in honour of the eminent investigator of the geology of Scotland, who called attention to the series of oolitic beds in Skye.

POTAMOMYA? SOWERBII. PLATE V. fig. 2 *a*, 2 *b*.

Shell transversely ovate, subequilateral, inequivalve (?), rather tumid, somewhat expanded anteally, frontal margin rounded, surface striated by lines of growth, beaks prominent. Breadth 1 inch and $\frac{3}{12}$ths, length $\frac{9}{12}$ths of an inch, thickness half an inch.

This is the "bivalve referable to *Unio* or *Anodon*" of Sir Roderick

Fofsils of the Staffin Oolitic Shales.



W. H. Baily. Printed by Hullmandel & Walton.

1. Perna Murchisonii. Forbes.
2. Potomomya? Sowerbii. "
3. P. " ? Sedgwickii. "
4. Ostrea Hebridica. "
5. Unio? Staffinensis. "
6. Cyrena arata. "
7. 8. Cyrena Jamesonii. Forbes
9. C. " Cunninghamii. "
10. C. " Maccullochii. "
11. Trigonia tripartita. "
12. Rifsoa (Hydrobia) conulus "
13. Neritina Staffinensis "

Murchison's list, and I have figured and described it from his specimen, the only one found. The true generic position of it and the next are very doubtful. I have dedicated it to Mr. J. De Carle Sowerby, who drew up the catalogue quoted of the oolitic fossils of the Hebrides.

Potamomya? Sedgwickii. Plate V. fig. 3 *a*, 3 *b*.

Shell transversely elongated, inequivalve?, subcompressed, tumid near the beaks, rounded at both ends, most produced and dilated anteally, marked by concentric furrows of growth. This evidently distinct, yet, in the absence of better specimens, obscure shell, is the "transversely elongated bivalve not yet named or figured," compared with a Wealden shell, in Sir Roderick Murchison's list. I have dedicated it to Professor Sedgwick, who jointly with Sir Roderick Murchison examined the geology of Loch Staffin.

January 22, 1851.

Thomas Webster Rammell, Esq., and Robert Rawlinson, Esq., were elected Fellows.

The following communications were read:—

1. *Memorandum respecting* Choristopetalum impar *and* Cyathophora? elegans. By William Lonsdale, Esq., F.G.S.

I. In the volume of the Palæontographical Society for 1850, M. Milne-Edwards and M. Jules Haime state that *Choristopetalum impar* does not appear to them to belong to the class *Zoantharia*, but is in their opinion a Bryozoon*—the grounds of dissent not being however mentioned. When the description of the fossil, published in the Quarterly Journal of the Geological Society†, was under preparation, the author's attention was necessarily called to the class *Bryozoa*, in consequence of the generic name *Heteropora* having been assigned to some of the specimens previously to their coming into his possession; and it was not until all the detected structures had been carefully considered, that the fossil was referred to *Zoantharia* or *Anthozoa*. In the description, the visceral receptacles are stated to be tubular, and the tubes to be crossed at irregular levels in adjacent receptacles, by transverse laminæ or diaphragms‡—'tabulæ' of M. M.-Edwards and M. J. Haime; and these structures are carefully delineated by Mr. J. de Carle Sowerby in plate 4. fig. 6+, particularly as respects

* *Op. cit.*, Memoir on British Fossil Corals, p. 70.
† Vol. v. p. 66–77.
‡ *Loco citato*, p. 66, l. 22, 24; p. 68, l. 12 from bottom *et seq.*; p. 69, l. 10 *et seq.* and 23; p. 70, l. 17, also last line with continuation in p. 71; p. 71, l. 32 *et seq.*

the diaphragms being on different levels (fig. 6 + near the bottom and left side), the continuous line representing the boundaries of two concentric layers*. It is further stated more than once†, that transverse laminæ are wanting in tubular *Bryozoa* or Ascidian polypes; but are characteristic of *Anthozoa* (*Zoantharia*); yet their existence in the lower greensand fossil is not denied by M. M.-Edwards and M. Haime. In the specimens examined, the structure was frequently absent, being one of the most perishable portions of stony corals; but it occurred sufficiently often to prove, that it was an essential component of *Choristopetalum impar* ‡; it is moreover, even when present, not always easily to be detected in tubes of very small calibre. In *Chætetes*, the want of cross laminæ was one of the characters on which the genus was founded, but that diaphragms exist in the typical species cannot be doubted. If it should be urged that cross laminæ are not a constant structure among *Corallaria*, being totally wanting in true *Alcyoniæ*, it must be stated, that either diaphragms or an equivalent component prevail throughout the class generally; while it remains to be shown that they occur in any genus of *Bryozoa*. The suborder *Zoantharia tabulata* of M. M.-Edwards and M. Haime is based on their existence §. One of the peculiarities of the lower greensand coral is the facility with which it separates into layers on mechanical force being rightly applied; and examples of the severed surfaces are represented by figs. 7 and 8 ||, the characters thus displayed agreeing also with those of tolerably preserved exteriors ¶. The larger openings, in both cases, led directly into the visceral tubes; but they might be mistaken for the apertures of cells, or of tubes limited in extent to the thickness of a layer. It is however stated in the description**, that the under surface of the detached portion presented a counterpart to the surface from which it had been severed, or apertures of similar dimensions; and that the former had manifestly been moulded on the latter. The larger openings constituted, therefore, a direct communication from layer to layer, and were not the apertures of cells or short tubes, but had been, for a time, the upper extremities of continuous tubes or visceral cavities periodically elongated and crossed at irregular intervals by diaphragms. It is therefore believed that the fossil was rightly assigned to the class *Anthozoa* (*Zoantharia*), and the author must maintain that opinion till the data are shown to be erroneous.

II. With respect to *Cyathophora? elegans*, M. M.-Edwards and M. Haime state, that they do not quite understand the reasons by which the describer was guided in referring with "a sign of doubt" the lower greensand fossil to the *Cyathophora* of M. Michelin, a genus, which, in their opinion, does not differ from true *Stylina*††. It is

* P. 72, last l. and p. 73.

† P. 68, l. 6 from bottom, p. 70, l. 12–21 and l. 7 from bottom.

‡ P. 71, l. 32–35.

§ Comptes Rendus, 1849, p. 260. Palæontographical Society, vol. for 1850, Mem. Brit. Foss. Corals, Introduction, p. lvii.

|| Quart. Journ. Geol. Soc. vol. v. pl. 4; consult also p. 72, last line, and p. 73.

¶ Fig. 11, and p. 71, l. 21.

** P. 73, l. 17 from bottom *et seq.*

†† Pal. Soc. vol. for 1850, p. 71.

said in the description that the noticed agreements between the French and English corals were few * ; nevertheless that no structure had been detected in *Cyathophora Richardi* which did not exist in the British zoophyte (*loc. cit.*). The points of agreement refer to the characters of the visceral cavities, also to the limited range centrally or across the diaphragms of the lamellæ † ; and the reader will find a great amount of agreement in the longitudinally exposed visceral cavities of M. Michelin's fig. 1 *a* ‡, and those truthfully delineated by Mr. de Carle Sowerby §, particularly in the interior distinguished by a +. It is also mentioned, that the manner of producing additional cavities was probably similar in each fossil ‖. The characters of the spaces between the abdominal receptacles of *Cyathophora Richardi* are neither delineated nor described ; but weather-worn or abraded portions of the lower greensand coral showed as little of the real nature of the intervals as the delineations in the 'Iconographie Zoophytologique ¶.' So far therefore as a comparison could be carried, an agreement existed ; and not feeling justified in assuming, that the undelineated and undescribed parts of the French fossil resembled the equivalent portions of the English zoophyte or differed from them, the author conceives that he decided rightly in referring the lower greensand coral provisionally to M. Michelin's genus ; but in the original notice he however added, should palæontologists hereafter show, that in the unascertained structures of *Cyathophora Richardi* there is a decided difference, the name of *Holocystis* might be adopted for the Atherfield fossil **. The name has been adopted, but the unascertained structures have not been described ††. M. M.-Edwards and M. Haime remark, however, that *Cyathophora* does not in their opinion differ from true *Stylina* ‡‡ ; and they state in the 'Annales des Sciences Naturelles §§,' in the synonyms to *Stylina Bourgueti*, that *Cyathophora Richardi* "ne nous semble différer du polypier que nous décrivons que par le mauvais état de conservation." The author of this Memorandum has never seen a specimen of *Styl. echinulata*, the coral on which Lamarck founded his genus ; but MM. M.-Edwards and Haime ‖‖ identify M. Michelin's *Styl. Gaulardi* ¶¶ with it, stating moreover that the figure (5) is "assez bonne," and condemning the representations of Schweigger *† and De Blainville *‡. A careful consideration of M. Michelin's figure just quoted, as well as of his delineation of *Styl. tubulosa* *§, a species recognised by the authorities so often mentioned *‖, assisted by the remarks on *Stylina* given in the 'Annales des Sciences Naturelles *¶,' has not enabled the author of this Memorandum to detect in *Cyathophora Richardi*, as delineated, and no doubt truthfully, the essential structures of *Stylinæ*. The

* Quart. Journ. Geol. Soc. p. 83, l. 27.

† P. 83, l. 5 *et seq.* ; p. 82, l. 11 from bottom.

‡ Icon. Zooph. pl. 26.

§ Quart. Journ. Geol. Soc. pl. 4. fig. 13.

‖ P. 83, l. 25.

¶ Quart. Journ. Geol. Soc. p. 82, l. 1 from bottom, and continued p. 83, l. 1–3.

** P. 83, l. 17 from bottom.

†† Pal. Soc. vol. for 1850, p. 70, 71.

‡‡ *Op. cit.* p. 71.

§§ Troisième série, t. x. p. 291, 1848.

‖‖ Ann. Sc. Nat. t. x. p. 289.

¶¶ Icon. Zooph. p. 97. pl. 21. fig. 5.

*† Beobachtungen, pl. 7. figs. 63 *a–d*.

*‡ Man. d'Actinol. pl. 62. figs. 5, 5 *a*, *b*.

*§ *Op. cit.* p. 97. pl. 21. fig. 6.

*‖ Ann. Sc. Nat. p. 289.

*¶ P. 288.

transverse and in some places complicated laminæ seem to him to bear the characters of true diaphragms, and to be seated within the visceral cavities; whereas the concave or transverse laminæ in M. Michelin's delineations of *Stylinæ** are without the cavities. M. M.-Edwards and M. Haime give moreover the following as one of the generic characters: "Polypiérites très allongés, unis entre eux au moyen d'un grand développement des côtes et de l'exothèque †." The internal composition of the visceral receptacles is, unfortunately, not shown in the figures before quoted; but if rightly understood, they are traversed vertically by lamellæ ("cloisons," MM. Edwards and Haime), the broadest of which touch the columella ‡, while no mention is made of diaphragms. On the contrary, M. Michelin says, the lamellæ composing the terminal star in *Cyathophora Richardi*, "couvrant à peine la moitié de la superficie de la dernière cloison" (diaphragm); and no allusion is made to a columella §. M. M.-Edwards and M. Haime acknowledge fully the difficulties which they encountered in determining the species of *Stylinæ* described by them; and it is impossible to doubt, that the evidence to which they had access was thoroughly considered before they concluded that *Cyathophora* differs not from true *Stylina* ||. The author of the present notice wishes only to maintain that he was justified in drawing the inference which he did from the data before him, while to have gone beyond them would have rightly made him amenable to censure; and he conceives that he would have erred, if, during his search for information, he had considered the fossils (*Styl. Gaulardi* or *echinulata* and *S. tubulata*) delineated by M. Michelin in pl. 21. figs 5 and 6, to be generically allied to the coral (*Cya. Richardi*) represented in pl. 26. figs. 1*a*, 1*b*.

In the description of *Cyathophora*? *elegans* ¶ allusion is made to the *Astrea alveolata* of Goldfuss **; and that fossil is included, as well as *Cya. Richardi*, among the synonyms to *Stylina Bourgueti* ††, with the remark, "nous paraît être un échantillon dont les chambres se seraient remplies après la disparition des cloisons et de la columelle." By the kindness of Mr. Wilson, of Lydstip House, near Tenby, the author has been able to examine a named specimen of *Astrea alveolata*. It agreed perfectly with Goldfuss's fig. 3*a*, but the specimen, though fine, being silicified, had the subordinate structures much obscured by the concretions due to mineralization. No doubt, however, could be entertained that the visceral cavities were crossed more or less horizontally by diaphragms—that a central axis had never existed —and that the lamellæ extended only to a limited distance, the most projecting in the best-preserved examples being six in number—Goldfuss says six or eight. The nature of the specimen prevented the detailed structure of the lamellæ from being fully ascertained; but they clearly ranged from one cavity to the next, as represented in

* *Loc. cit.*

† *Op. cit.* p. 287.

‡ Ann. Sc. Nat. *Styl. echinulata*, p. 289.

§ Icon. Zoophy. p. 104.

|| Pal. Soc. vol. for 1850, p. 71.

¶ Quart. Journ. Geol. Soc. vol. v. p. 77, l. 21 *et seq.*

** Petref. p. 65. tab. 22. fig. 3*a*, 3*b*.

†† Ann. Sc. Nat. p. 290–291.

the 'Petrefacten,' figs. 3*a*, 3*b*, and in *Cyathophora? elegans** ; cells were also exhibited in some places between the visceral receptacles, and similar to those expressed in fig. 15, Pl. 4. of the Society's Journal; the mode of developing additional cavities was likewise the same in both fossils, as well as the general habit of growth. It is therefore inferred that *Astrea alveolata* is not a *Stylina*, but is generically allied, as before conjectured, to the lower greensand coral, whatever appellation may be ultimately adopted for the latter.

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2. *On Supposed* Casts *of* Footprints *in the* Wealden. By S. H. Beckles, Esq.

[Communicated by the President.]

[*Abstract.*]

Certain large trifid bodies, presenting a resemblance to the casts of the impressions of birds' feet, are rather numerous in the cliffs to the east and west of Hastings (from the latter locality Mr. Beckles has obtained eight specimens), in a limestone containing *Cyrenæ*, remains of *Lepidotus*, &c., and Dr. Mantell has discovered a specimen in the Wealden of the Isle of Wight.

Several specimens, detached from the cliffs, have been taken from the beach; but at about four miles east of Hastings, where the cliffs are about 200 feet high, the casts occur at about 40 feet above the sea-level. They were found in a stratum of rock, overlying a bed of clay; which latter having been removed by rain and weather, the casts appeared in relief on the under-surface of the rock, just as if they were hanging from the ceiling of a room.

One detached block obtained at this place bears four of these trifid bodies in relief; they are arranged with the toes pointing in a uniform direction, so as to mark out a nearly perfect square. A distance of 2 ft. 7 in. separates the two in front, and 2 ft. 5 in. the hinder two: between the two on the right, from the toe of the hinder one to the heel of the foremost, there is a space of 2 ft. 3 in.; and between the other two the distance is less by nearly 2 inches.

The largest specimen found has a length of 21 inches.

The general uniformity of position and of character,—the constant presence of a middle or heel-like prominence and of three "toes," the central one being always the longest, together with other uniform peculiarities,—have reference apparently to the connection of the origin of these trifid bodies with the foot-prints of birds or other animals.

Some specimens, as for instance that of which a model was presented to the Society by Mr. Taggart in 1846†, have narrower "toes" than others.

* Quart. Journ. Geol. Soc. vol. v. pl. 4. figs. 12, 12+.
† See Quart. Journ. Geol. Soc. vol. ii. p. 267.

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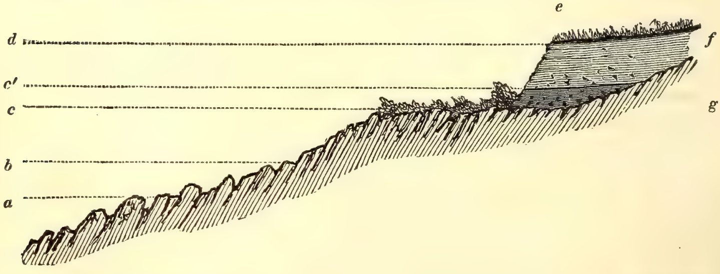
3. *On the* Superficial Accumulations *of the* Coasts *of the* English Channel, *and the* changes *they indicate.* By R. A. C. Austen, Esq., F.R.S., G.S. &c.

The geological phænomena which form the subject of the present communication have hitherto been included under notices of "Raised Beaches," or of "Recent Changes of Level;" they have invariably been considered as illustrations of the latest vertical movements of the earth's crust, as referable to one single period of time, and as mostly of small amount. My object will be to show that the phænomena in question are much more complicated, that they imply a vast period of time, that one most important character has been entirely overlooked, and that taken together they help to explain the history of what is perhaps the most striking of the changes in its physical conditions which the Northern hemisphere has experienced—namely those which occurred during the Pleistocene period.

The consideration of the evidence which any one of these masses, known as raised beaches, presents, will be the best introduction to the notices which follow. It must be borne in mind that no traces of such accumulations, sufficiently clear for our purpose, will be found along those parts of the coast-line of the English Channel which consist of yielding strata; from which we may infer *that the period of the present sea-level has been of sufficient continuance to allow of the cutting back of such coast-line to points beyond the original extension inland of such accumulations.*

The phænomena to be described are to be first observed on the coast of Devon, at the point where the older slates and limestones

Fig. 1.—*Section West of the Entrance into Dartmouth Harbour.*



a. Level of Fucus vesiculosus.
b. Zone without marine vegetation.
c. Upper tidal zone of a former level.
c′. Upper level of old marine beds, in former sea-cliff.
d. Surface bed of vegetable mould, formed out of a bed of marine sand and shingle.
e. Ancient sea-cliff.
f. Subaërial beds. Thick accumulations of earthy materials, with angular fragments and blocks of slate.
g. Slate-rock.

emerge from beneath the new red sandstone, and they are thence continued on interruptedly; the completeness with which they are presented depends much, even there, on the manner in which the rocks of the coast-line yield to the action of the sea, and on the dimensions which one component portion has acquired.

The sections taken about the point of land forming the west side of Falmouth harbour, and at low water, give an outline such as is represented by Section No. 4. Pl. VI. A similar condition of coast is shown in fig. 1.

The lowest zone (*a*) is that of the thick growth of Fucus, the upper limit of which presents a true horizontal line, and which may be taken, as suggested by M. Bravais (Voyages en Scandinavie, &c., p. 67), as that of the mean sea-level.

The zone next above this (*b*) presents a clean surface of rock, without marine vegetation, and its uppermost limit is that of the maximum rise of the tide. At the spot where the section fig. 1 is taken, there is no beach even at low water; the materials of the sea-bed are found only as patches of sand, shingle, and broken shells filling the hollows and inequalities of these zones: these two zones form the tidal belt of the present sea-level.

§ 1. Higher than this last, there is again another very distinct zone (*c*) presenting a rugged surface of rock, overgrown with grey and orange lichens, and having the hollows filled with tufts and masses of grasses, Armeria, Plantago, Erythræa, &c., rooted in sea-sand. This zone extends upwards to the base of the cliff (*e*); it is now wholly and permanently beyond the reach of the sea, *and is the upper tidal zone of a former level*, when the sea reached and formed the cliff at (*e*); it indicates a change of level, which so far as elevation is concerned, is necessarily the most recent which has taken place on this section, and which we may estimate at 8–10 feet.

The horizontal breadth of this zone (*c*) from place to place, depends on the form of the outline of the sea-margin between tides, when the land stood at the former level: often, as at the west of the entrance to the harbour of Dartmouth, see fig. 1, the outline is nearly that of a platform: in these cases there is often such a thick growth of vegetation as to conceal the features above described: the evidence of its origin as a true marginal sea-zone is to be found by the removal of the surface turf, when the loose sea-sand with rolled and broken shells will be usually found beneath.

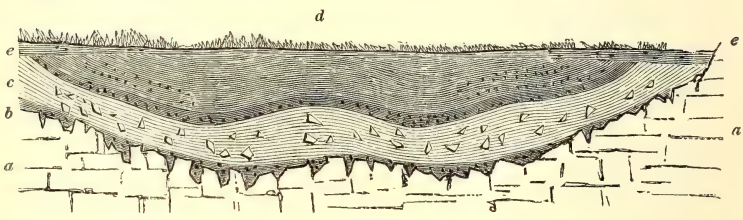
I have selected Falmouth and Dartmouth, as they are places of easier access than most others; because the evidence is to be clearly seen there; and because the amount of vertical rise, which is the same at both places, can be easily determined.

About the coasts of the whole of the group of the Channel Islands there are sections which are the exact counterparts of the foregoing, and where, owing to a rise of small amount, the sea does not now reach a line which clearly marks its former level (see fig. 2).

The features above described, illustrative of the latest alteration of the sea-level, belong to places situated on the open coast; and to this period of the lower level of the land, I would refer such accumulations as those of the valley of the Exe (Geol. Trans. vol. vi. p. 440), inasmuch as a depression of from 8–10 feet would convert the whole of that area, as high as Exeter, into a salt-water estuary, and account for the beds of *Mactra, Tellina,* and *Cardium* found at Alphington. To the west, the uppermost portions of the valley accumulations of Cornwall, as those of Pentuan (Section No. 1. Pl. VI.), belong to this level (De la Beche, Report on Devon and Cornwall, p. 401). Without multiplying instances, many of which will readily occur to most geologists, evidence of a like change of level can be traced up Channel, as far eastward as the valley of the Ouse in Sussex, where the former spread of the waters of the sea, over the low tract about Lewes, was long since pointed out by Dr. Mantell: here too the amount of elevation most closely corresponds with that on the west.

The level of many accumulations of sand and shingle, at small heights above the reach of the sea, would also refer them to this last change of relative position. Of these we may notice those of the low ground east of Cherbourg, and those along the west coast of the Cotentin; like beds may be seen around the Channel Islands, such as those from St. Helier's towards Mont Orgueil, and in Guernsey, particularly about the north end of the island.

Fig. 2.—*Section at St. Sampson's, Guernsey.*



a. Granite.
b. Surface of the underlying rock covered by rounded pebbles of granite.
c. Granitic sand with large angular fragments of granite.
d. Sea-sand with pebbles.
e. Horizontal layers of sand.

Fig. 2 was taken from a section of superficial accumulations exposed in St. Sampson's parish: the upper surface of the granite is very uneven; upon it are rounded boulders of granite, covered by a considerable thickness of granitic sand, containing large angular fragments of granite; above this is pure sea-sand and pebbles, with one principal seam of shingle, the whole so far conforming to the outline of the subjacent rock: the uppermost layers of sand are horizontal and have cut across the lines of deposition of the lower portion of the mass, the result of the movements of the water, under less depths than those at which the sands were accumulated.

In the construction of the sea-wall from Tor Abbey towards Paignton, beds of *Sabellaria* were cut through at about high-water line; the upper limit of these animals is below that of mean sea-level; these beds would thus indicate a rise of at least half the amount of the tide at this place.

These former upper tidal zones, with their corresponding raised marine and estuary beds, are the only portions of those indications of of

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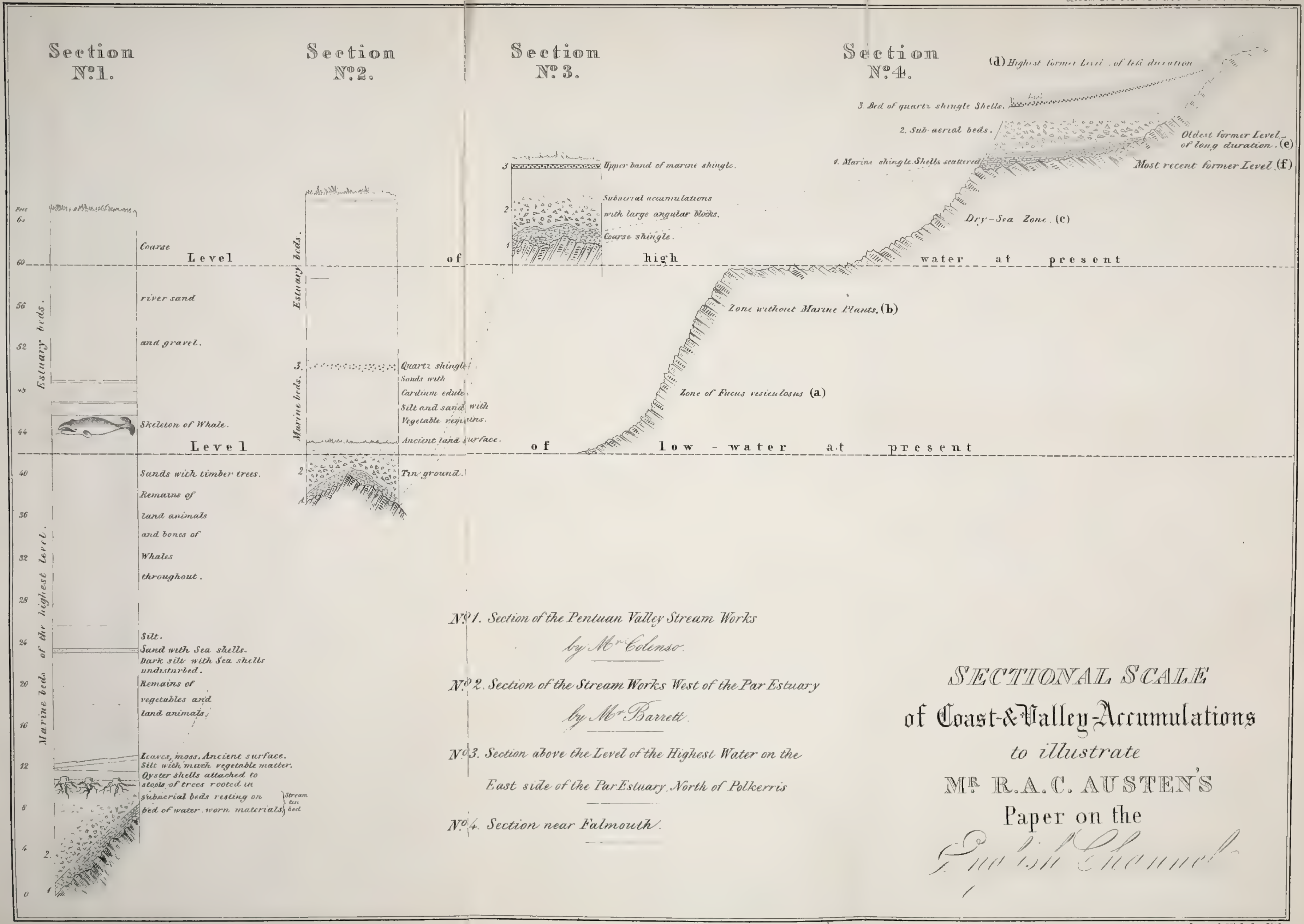
Section No. 1.
Section No. 2.
Section No. 3.
Section No. 4.
Feet
64
60
56
52
48
44
40
36
32
28
24
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16
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Estuary beds.
Marine beds of the highest level.
Coarse
river sand
and gravel.
Skeleton of Whale.
Sands with timber trees.
Remains of
land animals
and bones of
Whales
throughout.
Silt.
Sand with Sea shells.
Dark silt with Sea shells undisturbed.
Remains of
vegetables and
land animals.
Leaves, moss. Ancient surface.
Silt with much vegetable matter.
Oyster shells attached to
stools of trees rooted in
subaerial beds resting on
bed of water worn materials.
Stream tin bed
Level of high water at present
Level of low-water at present
Estuary beds.
Marine beds.
Quartz shingle.
Sands with
Cardium edule.
Silt and sand with
Vegetable remains.
Ancient land surface.
Tin ground.
Upper band of marine shingle.
Subaerial accumulations
with large angular blocks.
Coarse shingle.
(d) Highest former Level of less duration
3. Bed of quartz shingle Shells.
2. Sub-aerial beds.
1. Marine shingle Shells scattered.
Oldest former Level of long duration. (e)
Most recent former Level (f)
Dry-Sea Zone. (c)
Zone without Marine Plants. (b)
Zone of Fucus vesiculosus (a)
No. 1. Section of the Pentuan Valley Stream Works
by Mr. Colenso.
No. 2. Section of the Stream Works West of the Par Estuary
by Mr. Barrett.
No. 3. Section above the Level of the Highest Water on the
East side of the Par Estuary North of Polkerris
No. 4. Section near Falmouth.
SECTIONAL SCALE
of Coast-&-Valley-Accumulations
to illustrate
Mr. R. A. C. AUSTEN'S
Paper on the
English Channel.

changes of level which can with any fitness be referred to what may be considered as a "recent period." When we bear in mind the great extent of the area of the English Channel which is comprised within lines connecting the several places which have been here noticed, we may safely infer that this last change has been a uniform one throughout. Without entering into unnecessary details with respect to areas beyond the English Channel, it may be stated generally that there is abundant evidence of a like change of relative level of small amount, over that of the German Ocean.

§ 2. The next level, in chronological order, at which we meet with evidence of a former reach of the sea-margin, is in position (*d*) on sections No. 4. Pl. VI. and fig. 1: we there constantly find sea-sands, thin seams of pebbles, and shingle, with the common shells of the coast. The thickness of these beds is never very great, and at elevations of 30 feet they show clear indications of belonging to the upper marginal sea-zone. They become distinct only when they rest on the summit of the accumulations to be next described; where they come in contact with older sea-beds, the line of separation is not usually clear. The older sea-beds are more consolidated, and their upper surfaces are worn smooth in places. Instances of this level are to be seen in the coast-sections west of Falmouth, and in those of the Prawle and Start district, to which the foregoing observations more particularly apply; here the upper portion is often included in the band of dark vegetable mould, unless where local circumstances have favoured the subsequent accumulation of earthy materials. Marine beds of this age occur in the Channel Islands' sections (fig. 2, *d*).

The estuarine deposits which would be the equivalents of the sea-beds of this level are those seen in the Pentuan section (No. 1. Pl. VI.), with which those of the other valleys of the West accord.

These beds are clear indications of another sea-level perfectly distinct from, and show a depression of the land of somewhat greater amount than, that of the lower level previously noticed. If some of the high level accumulations of shingle of the Lizard district are rightly referable to this period, as I am disposed to consider them for reasons which will be assigned when considering the beds next in descending order, the levels at which the beds of this age occur are not so uniform as those of the period last described. The subsequent rise of the land appears to increase as we proceed westwards.

§ 3. The accumulation of materials next in order on the typical section No. 4. Pl. VI. (2. Subaërial beds) occurs in a vast number of sections to be observed along the coasts of Devon and Cornwall; it has not entirely escaped observation, but as far as I can find, has only been incidentally noticed, and generally under the vague term of "head."

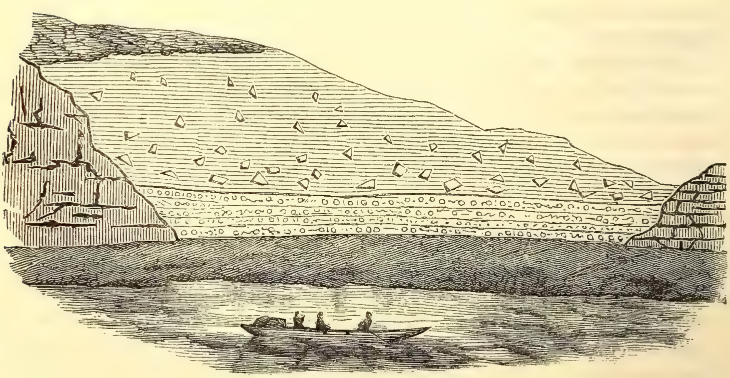
These beds, wherever found, are remarkably uniform in their general appearance and composition: they consist of fine earthy matter, such as would result from the decomposition of the rocks of the place; mixed with this are fragments of rocks of all sizes, ranging up to blocks of considerable dimensions: the fragments are obviously smaller in the upper portion of these accumulations than in the lower.

In places where the slope of the land is at a small angle, the "head" is mostly earthy, and of small amount; where it is steep, or rocky, it becomes in proportion thick and fragmentary: the component fragments will, in this case, be seen to have been derived in every instance from the masses of rock immediately overhanging—*the materials are always strictly local as to origin.*

These accumulations, as seen in cliff sections and at short distances, present an appearance of horizontal arrangement; closer examination, however, shows that this has nothing of the character of subaqueous arrangement: another very obvious feature is, that *the fragments are all perfectly sharp and angular*—no specimens of included water-worn rock are ever to be found.

A few localities at wide intervals, but at which these accumulations may be observed, and presenting their most instructive features, as to age and origin, may perhaps suffice. The blocks and fragments included in the mass west of Pendennis Point consist exclusively of the peculiar slates and included harder bands of that locality; the like occurs in the St. Austle Bay sections, particularly in the coarse beds at Polkerris. The accumulations about the bold headlands from the Bolt-head to the Start (and which when seen from the sea, at short distances from the coast, might be easily mistaken for horizontal stratified deposits) consist only of the waste of the hard fibrous and chloritic rocks of that part of the coast. To the west of Dartmouth the high slate hills contain intrusive veins of greenstone, and in the beds of debris which have been derived from them, we accordingly find greenstone fragments with those of the slate. In the limestone district of Torbay, as at Hope's Nose, as also in the Brixham side, the "head" is exclusively of limestone fragments.

Fig. 3.—*Section of "the Head" and old Marine Shingle at Tornanven.* (After Borlase.)



The accumulations which I have here noticed were long since so well described by Borlase in his 'Natural History of Cornwall,' that I cannot do better than refer to his representations of cliff sections, most particularly to pl. 9. fig. 4, and borrow a few lines from his account. "In a creek called Tor-nanven in the parish of St. Just, Penuith, near Cape Cornwall, in the north part of the cliff, inserted under clay and rubble, are ranged horizontally many rows of large and small rounded pebbles of the granite kind*. The covering of the pebbly stratum is 50 feet on the north, but only 20 feet on the south, consisting of rough yellow clay, *charged with large and small stones, all with their angles on.*" (p. 76.)

Besides the *local character* of this accumulation of earthy and angular materials, there is another allied fact of some value—viz. the absence of the slightest indications of any moving agent, such as that of a body of water in motion; this is shown in a very striking manner in many places, as on the west of Pendennis Point, where the beds attain a great thickness, are coarse and fragmentary, and are seen resting on a former upper sea-zone of loose sands; these sands are still as little coherent as if they had been thrown there by the last gale, but their surface is not in the least grooved or eroded along the line of junction.

The thickness which these accumulations attain is frequently very great; the mass described from Borlase varied as we have seen from 50 to 20 feet. West of Pendennis it may be estimated at nearly 30 feet, and reaches to 20 feet in the district of the Prawle. In the coast sections of the Channel Islands, I have measured it from a few feet to as much as 40. And everywhere about the shores of the western entrance into the Channel it is of sufficient thickness to constitute the line of low under-cliffs represented in figure 3.

These beds everywhere range inland above and beyond the level of the sea-beds on which they rest in the coast sections; and this position, with relation to two lines of definite sea-level, is one of the most interesting points in their history, as but for such intercalation the portions of the mass extending inland would be referred to that body of loose materials which is so constantly found resting on the fundamental rock strata, and whose age, but for this, would never be clearly ascertained.

As the beds which are here described are purely local, it may be as well, before speculating on the conditions under which they have been produced, to call attention to the very distinct character of the agencies *now* modifying the earth's surface, as compared with those which these older accumulations must have required. The general description of these beds already given has been derived from coast sections; in their extension inland, and to higher levels, they preserve the same characters, are earthy, fragmentary, and show a like decrease of the larger fragments in the upper, as compared with the lower portions. The upper surfaces of these masses of detritus are now necessarily receiving annually the accession of materials, from the joint operation of decomposition, and the transference of the products to lower levels; but, as may be seen in numerous valley sections, particularly over the slate districts of the south of Devon generally, the distinction between the coarse angular detritus below, and the fine earthy materials above, is always distinct: the nature and scale of

* Old sea-bed of the age of those to be next described.

Fig. 4.—*Headlands near the Prawle Point, South Devon.*

a. Slate-rock.
b. Low vertical cliff of the subaerial beds or "Head."
c. Sea-shore with protruding points of slate-rock.

the operations now in progress are limited to the conveyance of materials in the minutest state of subdivision, and imply only the conditions of slow atmospheric decomposition : no accession of fragmentary beds takes place now, nor has been made for some long time past. Such a condition, however, gradually shows itself, as we trace downwards the superficial accumulations of the interior of those districts whose coasts we have described ; such as those of the West of England, the Channel Islands, and the Cotentin : we everywhere may observe a passage downwards into beds which mark a time when the degradation of the surface proceeded much more rapidly than by the mere effects of decomposition, and when fragments of rock, and even blocks of large dimensions in certain localities, far exceeding the moving power of any rain-fall, were conveyed down the very slopes along which the minutest particles of matter only are now carried.

That the general surface accumulations of the West of England, the Channel Islands, and of the main land of the Cotentin, are of the same age, for their lower and principal portions, with those which in each of those districts are found overlying the older sea-beds, is clearly to be ascertained by tracing them away from such positions, up valleys which open out seawards, and so into the interior. In the coast section west of Falmouth, we see the beds in question resting on marine strata up to a given level, but when the outline of the country rises above such level, the beds of angular materials are still carried on, and rest on the fundamental slate rocks.

I have already noticed the local character of these accumulations, and also that in no instance over the large area where they occur, do they ever contain any water-worn fragments, or any which might not reach their present positions if only detached from some mass above : the thickness of the beds of detritus depends directly on the elevation of the ground with which they are connected, as also does their fragmentary character, and the dimensions of the blocks. In the Falmouth coast sections may be seen an instance, but which will occur to any observer in many other places, which serves to throw some light on the nature of the agencies engaged in producing these accumulations : here, at a place where the outline presents so small a slope that great power would be required to remove any coarse materials, we have on the surface of the rock a thick mass of angular fragments, and in this, the subordinate portions of the subjacent strata, such as the sandstone beds and quartz veins, are represented by strings of such materials running disconnectedly in lines through it. In this and like cases we have the effects of powerful mechanical disintegration, whilst the results of the process have remained *in situ*.

The white clays in the parish of St. Agnes, those of Trewidnek near St. Ives, 20 feet beneath the surface, as also those of Lenant and Madern, near Penzance, would seem to belong to the sub-aërial accumulations, from the evidence of the section of the strata of St. Agnes Beacon. The uppermost layer of rounded shingle would in this case belong to the upper high sea level (*d*) here described. The elevation of St. Agnes, upwards of 450 feet, would show the very unequal character of the movement of the land proceeding westwards.

The accumulations here described are exceedingly well exhibited in the Channel Islands, and will be there seen in many coast sections to attain a vast thickness; in such cases there is always high ground above from which the materials have been derived. Some geologists might, I imagine, at first sight be inclined to consider these masses to be simply the result of the surface decomposition of the granite. In these islands, however, there are numerous opportunities of observing the beds of decomposed, but undisturbed granite, for the process has in places extended to a great depth; these beds throughout their thickness, whatever it may be, show the veins and harder nodules occupying their natural places in the mass, and such nodules, if detached, are globular and never angular, as are the fragments included in the detritus beds with which we are now concerned: besides this, the blocks when derived from crystalline rocks have the precise angular forms into which such masses are naturally jointed; and with respect to the slates, the fragments have evidently resulted from a forcible splitting up of their planes of cleavage.

On such considerations as the foregoing, and also from the terrestrial conditions with which these accumulations are connected, I have proposed to consider this portion of the series of superficial beds as of *sub-aërial* origin (Report of Geol. Sect. British Assoc. 1849; Quart. Journ. Geol. Soc. vol. vi. p. 94). It only remains for me to add, that the thickness and positions of these beds are well represented in Sir Henry De la Beche's Sectional Views of the coast at Fistral Bay, New Quay, Braunton Barrows, Nelly's Cove, and between Rose-mulleon and Main-port; Report on Devon and Cornwall, by myself, in Trans. Geol. Soc. vol. vi. p. 441. They have been noticed by Prof. Sedgwick and Sir R. Murchison, in a paper "On the raised marine beds of Boggy Point" (Trans. G. S. vol. v.): "We there found," they observe, "that the top of this under-cliff was occupied to a depth of 8 or 10 feet, by a mixed detritus of *angular* fragments of the adjacent rocks, contained in a matrix of sandy loam."

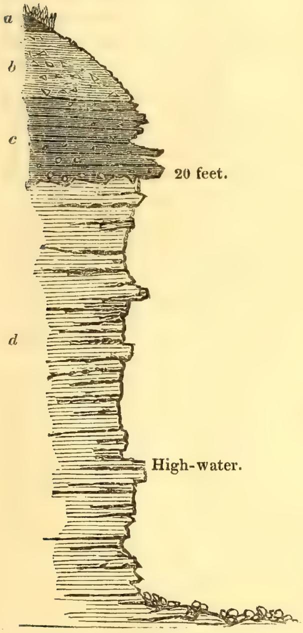
The portion of the superficial accumulation of the Sussex coast which Dr. Mantell has designated as the "Elephant bed" is of the same age and has originated under like sub-aërial conditions with those here described. It presents like characters of successive increase, and is composed of materials, such as the chalk-flints in particular, which, as observed by Dr. Mantell, have every appearance of having been exposed to the action of the atmosphere for a considerable time.

§ 4. In the section No. 4. Pl. VI., and in fig. 1, the beds which form the base of the vertical cliff (*e*) and underlie the accumulations last described, consist of coarse marine gravels, shingle, and sands, resting on an uneven surface of slate-rock, of which they fill up all the inequalities: they correspond at some places with the materials of the sea-bed of slight depths, and from this condition they are to be found of every intermediate stage, up to that of loose sand of high-water range. The sea-beds may in most cases be followed to some short distance, with a gradual rise, until they meet the base of a line of steep slope or cliff—the former coast-line of this period of level; this feature is very constant and distinct, and marks a permanent level of some considerable duration.

The characteristics of these lower sea-beds are, that they have become consolidated into hard compact masses of sandstone and conglomerate, that they contain materials derived from the greensand and chalk formations, and that, generally speaking, included marine testacea are scarce. Most of the "raised beaches" indicated by Sir H. De la Beche on the Ordnance maps of Devon and Cornwall belong to this period of sea-level, and of which those described are the most striking illustrations; it must not however be supposed that they occur only at the wide intervals at which they are there noticed; having visited them all in the course of the last summer, I can certify to the accuracy of the representations which Sir H. De la Beche has given.

I refer to this period, the marine beds on the east of Torbay (Geol. Trans. vol. vi. p. 441). On the opposite side of the bay, about Brixham, we find the like level maintained by the beds which cap the limestone cliffs (fig. 5).

Fig. 5.—*Section near Brixham, Torbay.*



a. Upper band of marine shingle, with superficial vegetable soil.
b. Subaerial beds.
c. Marine shingle.
d. Limestone rock.

On the west of Dartmouth we have as instructive a section as near Falmouth. The lower marine beds of Plymouth have been repeatedly noticed; and the Sections, No. 1–4, Pl. VI., will sufficiently explain the relations of the several successive conditions in St. Austle Bay.

The lower beds of sand and shingle from Brighton to Rottingdean, with fragments of crystalline rocks, I would refer to this period and level, so that we are enabled to comprise the whole length of the English Channel as having partaken of this movement.

We have therefore evidence of a third line of sea-level, distinct from the former ones, which taken from east to west does not appear to be so constant in its relations to that of the sea at present, and which was of sufficient duration to admit of the formation of sea-cliffs.

Before proceeding to the inferences and comparisons which the foregoing facts suggest, I will briefly recapitulate the series of changes indicated:—

1st. A narrow sea-zone, former sea-cliffs, and the presence of marine and estuary beds where is now fresh-water, showing a last rise of the land of from 8 to 10 feet for the whole of the East Channel area.

2nd. Superficial beds of sand, shingle, and marine shells, at greater elevation than the foregoing.
3rd. Great masses of detritus accumulated under atmospheric agencies and ending abruptly at the former sea-level, No. 1.
4th. Marine beds, subjacent to the foregoing, and attaining an elevation of from 60 to 70 feet above the present sea-level.

Such is a broad outline of certain changes, and which represents the extreme ranges of sea-level, at given definite periods, rather than the progressive stages by which they have been brought about. The Cornish valley sections, at one period—those of some of the river valleys of the French coast—the section described by Capt. James at another, might be made to represent transitional oscillations of small amount; but some of these phænomena may also be accounted for by such temporary changes as are now produced at the openings of valleys by the accumulation of banks of sand and shingle, and their subsequent removal.

Having so far confined myself to a brief and chronologic account of the evidences of certain changes of relative levels and former conditions of surface, I will now endeavour to assign to each its place and bearing in the physical history of the newer tertiary period. In a former communication (Quart. Journal, vol. vi. p. 88) I have given some reasons for considering the oldest marine beds here noticed (1, 1, 1, 1, in Sections, Pl. VI.) as referable to the pleistocene period of Sir Charles Lyell. By "pleistocene," however, I would merely be understood to mean generally the period which is marked by the first appearance of a northern marine fauna in sea-beds in our latitudes; or if this term is to be extended to the whole of that period which is subsequent to the first appearance of such marine forms, I shall endeavour to show that it was not one either of transitory duration, or of one uniform set of geological results; that although the mechanical effects or products of given areas of sea may be inconsiderable when compared with the formations of older periods, yet that the changes which followed the red and coralline crag period, indicate more contrasting conditions in physical geography than those of any other period with which we are at present acquainted.

It is however much to be hoped that the term Pleistocene, as well as its kindred subdivisions of the tertiary period, will ere long disappear from our geological nomenclature.

The sea which accumulated the red and coralline crag extended over and had its limits, on one side, on what is now part of the land of East England, with a much wider range over that of the continent of Europe on the other, thus indicating the existence at that time of an amount of depression over the German Sea area which the area of the English Channel had not. If any beds of the age of those in question occur in the valley of the Channel, it can only be at considerable depths beneath the present sea-level, otherwise some of the Crag forms would necessarily be occasionally washed up; we have no single fact at present to lead us to suppose that beds of this age occur there at all, whilst many other considerations tend to refer the area of the English Channel, during this period, to the condition of dry land. In making this statement it is necessary to add, that I of course refer the marine beds of the Cotentin, at Carantan, to the period of the lower marine beds of our own western coasts, and am quite prepared to find in them the same amount of specific peculiarities which the testaceous fauna of that side of the Channel now presents, as compared with that even of our western coasts.

As yet we possess no sure guide towards determining the condition of the surface area of the red and coralline crag subsequently to its completion, and prior to that indicated by the mammaliferous crag and its equivalents, for which latter period the relative position of land and water is sufficiently clear. The outline of the surface of the Eastern counties, as to lines of drainage, had been imparted prior to the period of the Norwich crag, inasmuch as the fluvio-marine portions of this formation (which are simply the indications of the places where rivers discharged into the sea) occur at the lines of the present drainage.

I propose to consider the older sea-beds (Sections, Pl. VI. 1, 1, 1, 1.) of the western portions of the English Channel area as of the same age as the Norwich or mammaliferous crag, a view which will be found to be in perfect accordance with the conditions indicated by their marine faunas, as also with the relative places which both sets of accumulations occupy in a well-marked series of oscillations. The lowest sea-beds of the Bristol Channel valley will represent this period of level in that quarter, when the sea may have reached inland to a considerable distance, for the beds at Kempsey are most probably of this age.

In this we have an outline of land and water very similar to that which is presented at present, as regards the relation of the South and East of England to the continent.

Next in ascending chronological order we have the accumulations described as the necessary results of sub-aërial conditions; and from the vast thickness which these masses present, along lines to which they have been cut back by a former sea-level, it is clear that they must at one time have had a very considerable extension seawards, or that originally they were carried on beneath the water-level by which they have thus been cut back. This implies a former elevation of the land, with relation to the highest upward range of the oldest sea-level (*e*, Sect. 4. Pl. VI.).

The most interesting inquiry which these sub-aërial masses suggest is that of the absolute *amount of the elevation* which this region then acquired: with respect to this point many general and local considerations afford us data for very reasonable suppositions, some of which, however, I do not propose to refer to at present. In nearly all the sections to which I have called attention we can distinguish the results of the meteoric agency of the present period. The composition of these beds shows that the transporting power is exceedingly limited. In the older sub-aërial accumulations, on the contrary, we have evidences, as already shown, of power sufficient to detach great blocks from the jointed masses of older rocks, to break up the fissile slates, and to accumulate the sharp and angular detritus in lower positions.

These phænomena so exactly accord with what is to be observed in all regions of excessive temperatures, whether resulting from geographical position or from altitude—they are so totally beyond the power of any present agencies, that it seems absolutely necessary to call in the operation of cold to adequately account for them. Many considerations oppose the possibility of low temperatures along the parallel of 50° N.L., whence these observations have been derived, and the only physical condition which I can imagine sufficient to account for the fragmentary detritus generally of the whole of those areas from which I have borrowed illustrations, is that of *an elevation of great amount, such as would place the whole of the higher portions of this country in regions of excessive cold.*

It can hardly be necessary to adduce proofs from those observers who have described the fragmentary disintegration of rocks, and the production of vast masses of angular debris, under the influence of Alpine or northern cold; such facts are familiar to geologists, and I would only refer to the observations of Professor Liebig*.

In the cause here proposed as sufficient to account for these old sub-aërial accumulations, I revert to one which I ventured to suggest many years ago with respect to the fractured and fragmentary masses to be found on the summits and upper slopes of the slate districts of the West of England†. I there stated that the only agent powerful enough to separate and break up the laminæ was that of excessive cold. This view is quite distinct from the popular one subsequently proposed by M. Agassiz of a "period of cold" or "glacial period." A period of great elevation, and extending over a wide European area, would explain a long series of allied phænomena, about which much obscurity yet hangs, but on the consideration of which we cannot enter in a communication limited to an account of the superficial deposits of the English Channel. As we are forced to admit that portions of the sedimentary strata of our island have at times been depressed some thousands of feet beneath the sea-level, at others they may have been placed as high above it. Such a supposition is in perfect accordance with all that geology teaches, far more so than any imaginary secular period of cold, dependent on astronomical changes.

The time allowed for communications to our evening meetings will not admit of the introduction here of those proofs by which it could be shown that the sub-aërial glacial phænomena of the whole of our British islands are synchronous with this period of elevation: in accordance with this supposition, the period of the glaciers of Great Britain and Ireland was simply one when the mountains of Wales, the Cheviots and Grampians, the mountains of Wicklow and Kerry, attained an Alpine elevation; it was from such sources that the rivers had their origin, which carried down the volumes of water which the breadth of their former courses seem clearly to indicate. This condition of things was not confined to our own limited area; many years

* My attention was called to this reference after the reading of this paper by Dr. Lyon Playfair; the ed. is the 2nd.

† Trans. Geol. Soc. vol. vi. p. 437.

since, when examining the broad alluvia of the Rhine and Rhone valleys, and speculating on the moving power and depths which these rivers must then have had, I recorded the impression that parallel conditions could only be found at present in the upper courses of the great rivers of northern India, and that the range of the Alps must at one time have had an elevation equal to that of the Himalayas.

The only remaining point connected with these sub-aërial accumulations to which I shall call attention, is that of their horizontal or seemingly stratified arrangement. This character, which, though very obvious at short distances, is hardly so when close, results from the collection of larger blocks and angular fragments at successive levels, as if the agencies, whatever they may have been, which have concurred in producing them were unequal, or greater at one time than at another: from the preponderance of coarse materials in the lower portions of these masses, we may also infer that they were greater at the commencement of the sub-aërial conditions than towards its close.

Of this period, so distinct in its physical features, we know somewhat of the vegetation and the terrestrial fauna.

On the west of the island of Guernsey is an area occupied by peat-beds and the stools of trees, and which by means of pond accumulations are connected with the sub-aërial accumulations; these beds are the higher portions of what forms the submerged peat and forest-ground of Vazon Bay. In the same island trees lie buried in the sub-aërial mass: in sinking a well through these at St. Pierre, after traversing 30 feet, the workmen reached what they supposed to be the solid granite on which it rested; the work was continued, when the obstruction was found to be a large block included in the superficial beds; beneath it was the stem of a large tree which had to be cut through. St. Owen's Bay in Jersey presents the same features as that of Vazon in Guernsey*.

The contents of the sub-aërial beds of our own side of the Channel long since attracted attention. Borlase notices the remains of land animals, and as a proof of their great antiquity, he states that the horns of the deer had become brittle, and dissolved readily in vinegar.

In Torbay the submerged forest-ground is apparently coextensive with the whole of that area, of which a continuous portion extends inland; the animal remains of these beds have not as yet been sufficiently made known by those who have become possessed of them; their dark colour and well-preserved condition easily distinguish them from the fractured and bleached specimens derived from the caves and fissures. The horns of deer have from their size and obvious nature attracted most attention. Bones of great size also occur, and the Museum of Natural History of Torquay contains a fine molar of an elephant, dredged up by a Brixham trawler at the entrance of the bay†. These remains are of much interest, as they serve to connect the age of this submerged forest-ground and the sub-aërial beds with which they are connected, with the period of the animals whose remains occur in the caves of the adjoining district.

* Vide Sketch of Geology of Channel Islands, Rep. Brit. Assoc. 1849.

† Prof. Owen, to whom I showed the specimen, informed me that it was a molar from the lower jaw of *Elephas primigenius*.

The facts recorded by Dr. Moore*, and which I had an opportunity of noticing, are of much interest: he distinctly states, what was perfectly clear, that the remains of the several animals (elephant, rhinoceros, deer, bear, &c.) occurred "on the top of the beach, and not in it." These remains also occurred in the limestone breccia (of sub-aërial origin) which filled the fissures, and which in other places overlaid the older marine beds. I do not adopt Dr. Moore's speculations as to the spot (the Hoe) having formed an island at low water when the land stood at the level indicated by the marine beds, to which animals may have carried their prey. Had the numerous animals whose remains occur there, lived on the land adjoining such beach, their remains would hardly have occurred solely on the top. The series of changes recorded at Plymouth is just such as has been recorded at other places along the coast:—1st. A lower series of marine beds. 2nd. A great elevation of the land, when the dry limestone ranges became a favourite haunt of numerous animals. 3rd. Its depression to a level rather higher than its former one, when such animal remains as occurred on the surface would become included in the mass of materials rolled about on the beach. The cetacean remains belong to the second period of sea-level, those of land animals to an antecedent one. The sea-level and its cliffs, with the older sea-beds, now mostly removed, was much below the position of the loose strata with rolled bones.

There is another consideration coupled with that of levels which connects the period of the large mammalian fauna of this part of England with that of the higher elevation of this district herein indicated. Certain caverns in which the numerous remains of animals have been found, occur at low levels, such as the caves of Yealmpton and Torquay; the lowest portions of this last present no accumulations of stalagmite†; we find only clay, including and covering clean surfaces of limestone: the animal remains do not extend to the whole thickness of the clay, but occur in the upper portion. Subsequently to the accumulation of the remains, the cave was evidently occupied by water; and lastly, the thick flooring of stalagmite was formed. At the period of the older sea-level this cave would be occupied by water, when no stalagmite would form; at that of great elevation, its occupation by animals, as well as the circumstance that a limestone mass so placed would not become overcharged with moisture, would also be unfavourable to its accumulation: in caves in dry situations new stalactite alone forms. The next subsequent sea-level would again fill the cave with water‡, and it is only at the levels subsequent to this that the flooring of stalagmite could possibly have formed.

If we now compare the conditions recorded in the area of the North Sea, subsequently to the accumulation of the beds of the Norwich

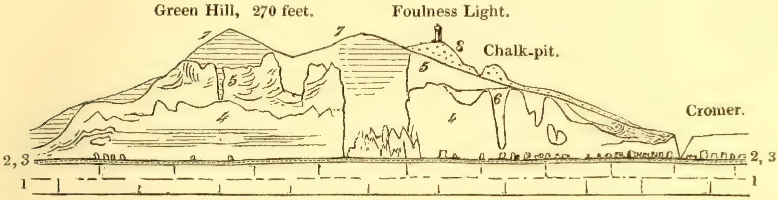
* Rep. of Brit. Assoc. 1841. Proc. Geol. Soc. vol. iii. p. 589.

† I noticed this fact in a short account of Kent's Cave (Trans. Geol. Soc. vol. vi. p. 444), and I find it confirmed in Mr. M'Enery's account of his researches in the same place. Mr. M'Enery's MSS. have passed into the possession of Mr. Ed. Vivian, by whom a portion has been published.

‡ This water would not be derived from the sea, but that which would collect at all inland places at or beneath the sea-level.

Crag, with those which the English Channel area has here presented, we see a like order of physical conditions in both. The beds of terrestrial origin at Runton and Mundesley, on the north-east coast of

Fig. 6.—*Profile of Cromer Cliff* (February 1824, R. C. Taylor, Esq.).



1. Chalk; exposed at low-water.
2. Laminated blue clay, with Crag shells; supporting
3. Stumps and branches of trees. Peat, bones of deer, elephant, &c.
4. Blue clay, with fragments of shells.
5. Brown clay, much disturbed and contorted; with fragments of similar shells to those in 3.
6. Detached masses of chalk.
7. Horizontal beds of sand, on an uneven surface of clay.
8. Sands and gravels.

Norfolk, show the conversion of an area previously covered by the waters of the early pleistocene sea into that of dry land, with subordinate alluvial and freshwater deposits, the whole covered by beds of marine origin (a second stage in the pleistocene period), and passing beneath the present level of the North Sea*. Mr. Trimmer states that the mammalian remains (elephant, deer, &c.) of this part of the coast are derived from the sub-aërial surface, and that local collectors give like testimony†. This view I consider to be the correct one, and that all the remains of animals found in the overlying till, have been derived in every instance from portions of the expanse of that former terrestrial surface. If we couple these considerations with what has been before stated respecting the broad alluvia of our former rivers, and their relation to the thick sub-aërial accumulations, and also bear in mind that similar conditions, and in like order, are presented on the opposite sides of the two areas of sea which now insulate this country; we may safely assume, as an ascertained point in the physical geography of a part of the pleistocene period, that at a time subsequent to the sea-level indicated by the Norwich Crag and its equivalents (and at that of greater sub-aërial elevation), this island formed part continuously with the dry land of the Continent of Europe, of which tract it then formed the western portion. It was during the continuance of these conditions, and which it is clear must have been of great duration, that the great mammalian fauna, buried in caverns, ancient lakes, and alluvia, attained its numerical maximum.

When the whole of the German Ocean was thus raised into dry land, the course of the Rhine must have been continued northwards

* Taylor was the first to point out this former terrestrial surface.

† On the Geology of Norfolk, Journ. Agricult. Soc. vol. vii. part 2. p. 459.

through it, with dimensions proportionate to the depths indicated by the alluvia in the higher parts of its continental course, and to the accessions it would receive from all those rivers which now discharge into the North Sea. It was on the banks of this vast river and on its islands that the herds of elephants lived, whose remains are so abundant and perfect beneath the waters of the German Ocean. By adopting the line of greatest depression along this area, we may even now conjecturally trace the course which this river then had, and it will be found to correspond in a very remarkable manner with that along which the large mammalian remains have occurred (See Map, Pl. VII.).

At this time, and in conformity with what many other considerations would lead us to expect, we find a wide-spread coniferous vegetation extending itself across the whole of the British Islands, from the coast of Norfolk to that of Cardigan, consisting of *Pinus sylvestris*, and, what is more interesting, of the *Abies excelsa**, from the whole of which tract the latter afterwards disappeared, until re-introduced by man. This, however, was not the case with the *Pinus sylvestris*, which appears to have lived on over those northern portions of these islands which were not submerged. From the Orkneys, where at present no trees can grow, to the area of the English Channel, we find a former like extension of coniferous trees, rooted in beds passing beneath the existing sea-level. It is with the growth of the Norway spruce that the large mammalia were contemporaneous in the East of England; and we have learned from the investigations of Prof. Owen (Fossil Mammalia, Introduction, Table, p. xlvi.) the very curious fact, that at the same time the Rein-deer and the Lagomys ranged into the south-western counties.

The westward extension of this former area of land may perhaps have had some relation to the greatest amount of elevation it then had, as compared with what it has now. The highest portions of the Dartmoor range, so far as I have been able to ascertain, afford no evidences of ancient glaciers. The greatest elevation of this region now is 2000 feet; while all the British ranges which afford indubitable proofs of such masses have at present an elevation considerably in excess of this. An extension of the land to the distance of the remarkable line of sudden depression which occurs at 200 fathoms (Quart. Journ. Geol. Soc. vol. vi. p. 86) would place the area of the British Islands under physical conditions sufficient to satisfy all the observed phænomena of a former permanent snow-line and broader rivers. In a paper to which this is partly a sequel, I have already pointed out some considerations which imply former littoral conditions along this line. To these may be added a very remarkable fact recorded by Capt. Martin Whyte, in his 'Survey of the English Channel,' and which adds great weight to the conjecture of an extension of the land equal to what is here assumed, that *Unio pictorum* was brought up from 50 and 100 fathoms water, in N.L. 48° 55′, W.L. 9° 28′, and in N.L. 51° 21′, W.L. 8°, fourteen miles from the nearest land (see Map, Pl. VII.).

* R. Brown,


MAP
OF THE PHYSICAL GEOGRAPHY OF
WESTERN EUROPE
during the
NEW TERTIARY PERIOD.
Lakes
Region from which Glaciers have depended.
Greatest extent of Land.
Insulated Areas at period of greatest depression.
Probably submerged land. E. Forbes
Shetland Is.
Line of depression (200 fms) indicating the former elevation of the land of Norway
Dogger Bank Long Bk.
Mammalian remains
Area strewed with remains of large extinct Mammalia
Unio pictorum
Cantal
Vosges
M. Blanc
M. Perdu

In the English Channel area, as we have seen, there are evidences of two distinct levels, as compared with that of the sea at present: the most recent, or that which formed the vertical coast line (*c*, fig. 1); the other, or that of the high-level sands, shells, and shingle. This last I would refer to the period of the greatest depression of the northern portion of the British Islands during the pleistocene oscillations. This movement, which commenced on the north and extended progressively southwards, was one to which certain areas in the south of these islands, dependent on E. and W. axes, were not altogether insensible. These areas, as I have shown (Quart. Journ. Geol. Soc. vol. vi. p. 91), formed a range of insulated lands during the whole of that period, and seem as it were to have been the hinge-line of that remarkable depression. That movement, which affected this line itself, was the latest in point of time, and the least in amount; and it was then, whilst the whole Northern hemisphere was one wide expanse of sea from the line of N.L. 51°, that the true whales, whose presence is so constant in the higher marine accumulations of the Channel (Pentuan, Plymouth, Ouze, Wye, Somme, &c.), ranged freely into these regions. The low temperature of this region, then, was the result of the wide extent of the Northern Ocean.

We obtain a measure of the low temperature of this period of greatest depression. Coast ice must have formed, occasionally at least, as low down as around the E. and W. line of unsubmerged land, as we can imagine no other means for transporting the large rocks of sandstones which occur in the deep shingle on the north of the Wealden area (see Quart. Journ. Geol. Soc. vol. vi. p. 89). Mr. Nicol has called attention (Quart. Journ. Geol. Soc. vol. v. p. 20) to the curious fact that the pleistocene mud of the Valley of the Clyde contains imbedded angular patches of sand. The explanation I believe to be this: on the breaking up of the coast ice, portions of the marginal zone of sand, also frozen, would be floated away with the blocks of ice; as the upper surfaces of these thawed, the lower and charged portion would sink; and if this happened over a sea bed of soft mud, they would bury themselves, and, being imbedded in the till, would preserve their angular forms when the particles of sand were no longer held together by ice.

These depressed latitudes again rose into the condition of dry land, of which the extension was much greater than that of our present limits, and included large portions of our surrounding seas. The distinctive features of this period—the passage from pleistocene to present conditions—though one upon which much has been written, is still one on which very much remains to be done, and which, if attempted here, would require more space than could be well allowed.

By the accompanying table I have endeavoured to obviate the detail and repetition of many known facts, which would have been necessary had I attempted to describe those changes and deposits which in adjoining areas I consider to be *generally* synchronous with those of the English Channel. It shows—

That several areas have continued as dry land from times anterior to the oldest Crag deposits.

That, with respect to movements of the earth's crust in this region, during a period which geologists have agreed to consider as one and indivisible, the oscillations have been great, both of depression and elevation, and that there has been at several distinct periods a constant return to a level very near the present one. The greatest amount of elevation and depression does not seem to have been uniform: a marked line of E. and W. physical structure has been least affected: during the period of the greatest extension of the Northern Sea, the amount of depression seems to have proceeded at a uniform progressive rate from S. to N., whilst with respect to the maximum of elevation the increase was from E. to W.

These former levels are to a great extent independent of the present relation of land to sea: the external configuration of the country had obviously been acquired prior to any of the successive conditions which have been here described; and the level of the sedimentary deposits of the South of England, which rise to a line of 900 feet above the sea, is simply the result of the last adjustment which has taken place, and by which former inequalities have been placed in common relation to the earth's curvature.

THE UPPER TERT

	Thames Area and	Continental equivalents.
..	1.	1.
&c.	*a.* ....freshwater	*a.* The continental equivalents of this period are common, from the coast of Denmark to that of Belgium. *β.* Ditto.
..	2. Drift: effects of co illips .. outline of Weald	2. Drift generally spread over N. Europe as low as 50° N. Lat. (Berghaus*).
...	*a.*	
an- d." sed re" the Di- ais. vith	3. Sub-aërial detritus lations of strict. aterworn," malian re-	3. Greatest elevation of the Alps, Vosges, &c.; also Pyrenees.
and	*a.* Wide alluvia of .... and Brentford (M Mole, Wey. Low bury.	*a.* Broad alluvia of Rhine, Rhone, Seine, Loire, and all the continental rivers.
..	*β.* Old terrestrial s of Norfolk tire skeletons of *I nius* beneath drif Petteridge, &c.	*β.* Rhine and affluents, continued northwards along bed of present German Ocean.
d of ain- ocks and	4. ....s)........	4.
its	5. The outflow of th n portion of Thames into the s sea at the nearly the same le d coralline but the volume of greater.	5.

* Physical Atlas, 1836.

TABULAR VIEW OF EQUIVALENT PORTIONS OF THE UPPER TERTIARY SERIES OF ACCUMULATIONS.

Isle of Man and St. George's Channel Area.	Severn and Bristol Channel Area.	West of English Channel Area.	East of English Channel Area.	Thames Area and Tributaries.	Norfolk and Suffolk.—R. C. Taylor, Rose, Trimmer.	Yorkshire.	Continental equivalents.
1. Most recent marine beds of Isle of Man (Cumming).	1. Uppermost sands and silts of Bridgewater levels, &c.	1. Latest elevation, 8–10 feet on open coasts. Torbay, Falmouth, Cotentin, Channel Islands.	1. ……	1. ……	1. Marine clay, with recent shells: Valley of the Nar.	1. ……	1.
a. Upper shell marl. Terrestrial surface (Cumming).	*a.* Terrestrial surface (Buckland, Conybeare, Horner).	*a.* Upper portion of the estuary deposits of Exe, at Alphington, and of the Cornish valleys, Fal, Pentuan.	*a.* Terrestrial surface. Hastings, &c.	*a.* ……	*a.* Terrestrial surface: freshwater beds of Gaytonthorpe.	*a.* Terrestrial surface: freshwater marls and peat beds.	*a.* The continental equivalents of this period are common, from the coast of Denmark to that of Belgium. β. Ditto.
2. Drift gravel, with chalk flints and sea shells. High-level marine sands and shells of Snowdon range.—N.B. The depression of the land was much greater here than in the W. of Irish Channel.	2. Drift—*passim*……	2. Highest level of marine shingle. Lizard, Falmouth, St. Austle Bay, Prawle, Plymouth, Guernsey, Jersey.	2. ……	2. Drift: effects of coast ice along N. outline of Wealden area.	2. ……	2. Drift. "Diluvium" of Phillips ..	2. Drift generally spread over N. Europe as low as 50° N. Lat. (Berghaus*).
a. ……	*a.* ……	*a.* Marine beds in valleys, with remains of *Cetacea*. Pentuan sections, Par Bay, Falmouth valley, Bovey valley, Exe.	*a.* ……	*a.* ……	*a.* Upper drift. Sands and gravel beds. β. Till-clay, with large fragments of crystalline rocks. γ. Lowest marine beds, with bivalves *in situ*. Runton; Chillesford and Iken (Prestwich).		
3. "Diluvium" of Cumming. "Loam of hill-sides and valleys." "Blue-brown marls," or "older alluvia," with *Megaceros*. Former terrestrial surface. Pine-forest of Cardigan Bay (Yates).	3. Lower angular local gravel of Prestwich. (Geol. Proc. vol. ii. p. 404.) Local angular gravel of Murchison. (Sil. Syst.) Local angular gravel of Exmoor range.	3. Sub-aërial accumulation; land at great elevation. Period of large mammalian fauna at its maximum.	3. Thick rubbly beds of chalk, with angular flints. "Elephant bed." "The flints have been long exposed to the action of the atmosphere" (Mantell). Broad alluvia of the Arun with Elephant remains. Diluvium of Rozet, in the Boulonnais.	3. Sub-aërial detritus of Wealden district.	3. Terrestrial conditions……	3. Lowest "rubbly accumulations of local materials, not waterworn," of Phillips, with mammalian remains.	3. Greatest elevation of the Alps, Vosges, &c.; also Pyrenees.
a. ……	*a.* ……	*a.* Wide river-courses—Fal, Dart, Teign, Exe, &c.	*a.* Valley of the Somme, &c., with remains of large mammalia. Tourbes du Diluvium of Rozet, and of Ravin for the Canche. Bournemouth, Avon, Wilts.	*a.* Wide alluvia of Thames at Kew and Brentford (Morris). Medway, Mole, Wey. Lower marls of Newbury.	*a.* Freshwater deposits and mammalian remains. Weybourne, Happisburg, Runton, Mundesley, Gorleston, Lowestoff.	*a.* ……	*a.* Broad alluvia of Rhine, Rhone, Seine, Loire, and all the continental rivers.
β. ……	β. Broad alluvia of Severn and tributaries. Recent freshwater species, with *Hippopotamus*, *Bos*, &c., beneath drift*.	β. Older peat bogs and forests, principally Pine. Bovey?; or at present often submerged.	β. ……	β. Old terrestrial surface, with entire skeletons of *Elephas primigenius* beneath drift. Peasemarsh, Petteridge, &c.	β. Pine-forest beneath drift, with peat beds. Happisburg, &c. *Abies excelsa*.	β. Prolongation of those of Norfolk coast (Taylor).	β. Rhine and affluents, continued northwards along bed of present German Ocean.
4. "Sands, gravels, and conglomerates. Red-brown marine marls." "Boulder-clay" of Cumming. Marine fauna.—*Vide* Forbes *apud* Cumming. Freshwater marls of Central Ireland*, terrestrial equivalents of. Pleistocene marine beds of Irish and Welsh coasts. Marine fauna like that of the Carentan beds.	4. Marine beds: inland†; Kempsey‡. Lowest marine beds on coast—Barnstaple, Baggy. Lower St. Colomb valley.	4. Lowest marine beds—Falmouth, Cornwall *passim*, Plymouth, Dartmouth, Torbay, Guernsey, and Jersey, neighbourhood of Carentan (Desnoyers).	4. "Ancient sand and shingle" bed of Mantell, at Rottingdean, containing pebbles, and rounded blocks of granite, porphyry, slate, and palæozoic limestone. *Equus*. Sea-shells.	4. ……	4. Norwich or Mammalian Crag (Charlesworth).	4. Bridlington Crag (Forbes)……	4.
a. ……	*a.* ……	*a.* Lowest marine beds in stream-tin valleys.					
5. ……	5. ……	5. Channel area dry land……	5. Dry land. *Mastodon*—probably its extreme northern range.	5. The outflow of the waters of the Thames into the Crag sea was at nearly the same level as at present, but the volume of water was much greater.	5. Red and Coralline Crag (Charlesworth).	5. The area of the Northern portion of the Yorkshire coast was sea at the period of the red and coralline crag.	5.
* The peat beds of Central Ireland present:—1. Fibrous peat, with the present vegetation. 2. A terrestrial surface with coniferous vegetation. 3. Old, or black and compact peat. 4. Oak-trees rooted in subjacent soil (marls).	* Cropthorne; Strickland. † Strickland. ‡ Prof. Buckman has pointed out the occurrence of salt-plants along the course of the Severn, and hence deduces its former occcupation by the sea.						* Physical Atlas, 1836.

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I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 5, 1851.

James Inglis, M.D., was elected a Fellow.

The First Part of the following communication* was read :—

On the Silurian Rocks *of the* South *of* Scotland. By Sir Roderick Impey Murchison, G.C.St.S., F.R.S. G.S. L.S., Hon. Mem. R.S. Edinburgh, R.I. Ac., Mem. Imp. Ac. Sc. St. Petersburgh, Corr. Mem. Ac. France, Berlin, Turin, Copenhagen, &c. &c., and President of the Royal Geographical Society, London. *With a List and Description of the* Silurian Fossils *of* Ayrshire. By J. W. Salter, Esq., F.G.S.

Introduction.

The rocks of the South of Scotland, to which attention is directed in the ensuing pages, have been more or less described by many of my predecessors and contemporaries. They constitute the greywacke and clay-slate of earlier geologists; and a few organic remains in their associated limestone did not escape the observation of Hutton†.

At that period, however, these few and rare organisms could not

* Part Second was read on February 26, 1851.

† Theory of the Earth, vol. i. p. 333. For their structure, see Prof. Jameson's first delineations of the S. Scottish Rocks, Memoirs Wernerian Nat. Hist. Soc.

have been made available in classifying the strata in which they occurred; since no distinction of the older palæozoic formations by means of imbedded fossils had then been attempted. Between the brilliant dawn of Scottish geology and the last few years, the fossils of these old rocks had altogether escaped attention. When, however, Professor James Nicol discovered certain forms in the schists of Peebleshire, he at once saw that they were of Silurian age by comparing them with the *Graptolites* published in the 'Silurian System.' About the same time, and a few years after the publication of my work upon the Silurian Region, Mr. J. Carrick Moore*, having collected *Graptolites* in Wigtonshire, referred the schists in which they occurred to the 'Silurian System;' and Professor Sedgwick, having subsequently visited that region and extended his researches with Mr. Moore, confirmed the view, having first considered the Ayrshire deposits to be Upper Silurian or Devonian†, and afterwards having classed them as Lower Silurian. Following on those researches, and after the publication of his excellent 'Guide to the Geology of Scotland,' Professor James Nicol gave us two memoirs on the Silurian Rocks of Peebleshire‡ and the Tweed§, in which he assigned strong grounds for believing, that the oldest rocks containing fossils in this region of Scotland were of the age of the Llandeilo group of the Lower Silurian Rocks. Another group of forms having been sent to the Geological Society from the environs of Kircudbright Bay, Mr. Salter pronounced them to be of the age of the Wenlock shale‖.

Having at various periods of my life traversed portions of this South Scottish tract, I had a strong desire to look at it more closely, now that it had been pronounced by others to belong to my own 'Silurian System.' I was the more stimulated to do so, by hearing from Professor Sedgwick at the last meeting of the British Association a verbal communication on the highly fossiliferous tract of Ayrshire near Girvan, from which, in addition to collections made there by Mr. J. Carrick Moore, he had procured many fossils, which had then been to a great extent named, and were about to be described for him by Professor M'Coy; preparatory lists of them being then announced. Knowing that Professor Sedgwick had been so unwell, when he last visited Girvan, that he could not work out with satisfaction to himself the natural sections of the interesting tract around that town, and also that he could not revisit it last autumn owing to his duties, I resolved to explore it before I looked at other points in the South of Scotland. Having obtained from my old friend every encouragement to do so (for we were together a few days in the South Highlands), I induced Professor Nicol to join me in these researches, and I need not say how valuable his co-operation proved, in consequence of his hard-earned acquaintance with the eastern and central portions of the South of Scotland.

Having first examined the clay-slate at the mouth of the Clyde, Professor Nicol and myself repaired to Girvan; and, after exploring

* Proc. Geol. Soc. vol. iii. p. 277.
† *Ibid.* p. 553.
‡ Quart. Journ. Geol. Soc. vol. vi. pp. 53 *et seq.*
§ *Ibid.* vol. iv. pp. 195 *et seq.*
‖ *Ibid.* p. 206.

the tract around it, we subsequently travelled through Wigtonshire, Galloway, and Kircudbright, and lastly made transverse sections across the central ridge in Dumfriesshire, the country which Mr. Harkness has recently described*.

In offering the following observations, no one can be more impressed than myself with the difficulty which must for some time prevail in producing a detailed monograph of the Silurian Rocks of Scotland. Their numberless dislocations and contortions would be difficult to unravel, even in a clearly exposed mountain-chain; but when we add to this, that, for the most part, the strata are obscured by vegetation, bogs, or drift, and also broken through by a variety of igneous rocks, every one will perceive that the task of placing them in their original order of succession is one which can only be accomplished by long-continued and close labour, such as has characterized the Geological Survey of England and Wales. This effort in physical geology might indeed, I am persuaded, be accomplished by persons like Professor Nicol and those who have begun it; but I do not desire to see good geologists set to such a labour of detail until the region be adequately laid down and mapped by the Government Geographical Surveyors. If Scotland be not freed from the disgrace of being almost the only country in Europe whose surface is not yet correctly mapped, it is vain that we can look for sound geological details. In the absence of such geographical data, the working geologist is discouraged in his first efforts to reform the maps hitherto produced, the chief one of which, usually known as MacCulloch's map, is so replete with errata, that although it would be a waste of time to attempt to enumerate them all, a certain number of them are subjoined in a footnote†.

* Quart. Journ. Geol. Soc. vol. vii. pp. 46 *et seq.*

† The following errata, chiefly drawn up by Professor Nicol, may be taken as samples of the defects of MacCulloch's Geological Map, and, although some of them have been remedied in more recent maps of the British Isles, very much remains to be done in correcting outline mistakes and erroneous classification.

In the south-east the sandstones of Roxburgh and Berwick are coloured as Red Sandstone, whereas a large part of them belong to the carboniferous or mountain limestone. This is also true of the same formation on the coast south of Dunbar, on the other side of the southern Silurian axis. The limits of these sandstones and of the other formations are in both places very inaccurate, and more especially in the upper part of Liddesdale. A great part of the trap-rocks in the sandstones is omitted. The igneous eruptions in the Silurian rocks are almost entirely passed over. Not a single trap-dyke is laid down, although some run continuously for many miles—one at least for nearly thirty. Whole hills of felspar-porphyry and syenite are coloured as clay-slate—as the promontory of St. Abb's Head, Cockburn Law, Priestlaw (the Fassney granite of Playfair), Derrington Law in Berwickshire, Wendestraw Law in Peebles, and Selkirk, with many others of less note, well known to Professor Nicol.

In the south-west all the granite and trap near the Mull of Galloway are omitted, and also the important trap-rocks and serpentines of Bennan Head, &c., and all the igneous rocks described in this memoir. The Silurian rocks N. of Girvan are laid down as Old Red Sandstone.

In the centre of Scotland no dependence can be put on what is coloured as Red Sandstone, or on what is laid down as Coal. The trap rocks are also very imperfectly delineated. In the Pentland Hills, for instance, many square miles coloured as trap are Silurian sandstone. Of the latter not a trace is seen in

But, beset as we are with numerous difficulties, no reason exists to prevent our elucidating those details which may serve to connect the stratigraphical geology of Scotland with that of other regions. By pointing out obstacles to be overcome, we enable others to gain the vantage ground. It is in this sense, and in the conviction that the time is arrived when some effort should be made to develope the earliest epoch of Scottish primæval life (the next æra of which, or the Old Red Sandstone, has been rendered classic through the clear descriptions and powerful reasoning of Mr. Hugh Miller), that this memoir is written.

Deriving as I have great benefit from the assistance of Professor Nicol, he is not, however, to be held responsible for all the opinions now published; and in justice to him I shall indicate a point of detail in which he entertains a hypothetical view differing slightly from my own.

Lastly, let me express the gratification I experienced, when, in turning over the pages of Hector Boetius in the Chronicles of Hollinshed (let no rigid critic interfere with my belief), I found that the very tract, in which there are strata undistinguishable in their aspect and fossil contents from the sandstones I had named after Caradoc or Caractacus, had been also occupied by tribes of the Silures! In short, it

the map. In the South-western Highlands, a large portion of Cantire, coloured as mica-slate, is sandstone and limestone, covered with trap, as recently shown by Professor Nicol. The lias of MacCulloch in Cantire is partly coal, partly recent tertiary, and partly a peat bog. Much of his primary limestone is a black basalt (see Edin. Phil. Journ. vol. xlix. p. 385, and Professor J. Nicol's account of Cantire, given to the British Association for the Advancement of Science, 1850). Further north the singular trap rocks on the coast (like those of Arran, &c.), are all passed over.

On the north-east, a great deal of trap in the Red Sandstone of Forfarshire and Kincardineshire is omitted. In the Grampians south of Aberdeen, there are trap and granite, both of which are not noticed. In the country round Aberdeen the boundaries of the granite and gneiss are incorrect, hills of the one rock being coloured like those of the other. All the region in and around the Forest of Glenorchy is most inaccurately given, and even in the easily accessible countries north and south of Loch Fyne and Loch Tay, long and persistent bands of limestone, so important in such tracts, are either omitted or occasionally marked as igneous rocks! In general, even where the map is tolerably correct, the formations are not distinguished as could now be done. The map is, in truth, more mineralogical than geological, but in the igneous rocks it has not even lithological merit. The felspar-porphyries are not separated from the traps, nor from the hornblende-rocks. In the absence of a correct geographical survey, MacCulloch may however be held excusable for the omission of many details and much inaccuracy of outline.

This national deficiency, through which all benefit of the application of the "Geological Survey of Great Britain and Ireland" has also been lost, will I trust be soon remedied by an adequate grant of money to produce a correct map on the scale of an inch to a mile. Making a first remonstrance on this subject in 1834, and vigorously reviving it last year (on both occasions at my instance), the British Association for the Advancement of Science, being supported by the proprietary and public bodies, including the Wernerian Society and the Royal and Highland Societies, has at length succeeded in directing the serious attention of the Government and Parliament to the untoward condition of the geography of Scotland. See Returns to the House of Commons. Trigonometric Survey of Great Britain and Scotland, 1836, no. 106, and 1837, no. 525.

would appear that the Silurian loved to dwell amid the relics of the old greywacke of the Scottish region, as well as on that of the head-quarters of his nation along the Welsh frontier. And thus I rejoice at having substituted a pleasing name, full of glorious British recollections, for the foreign term "*grauwacke*," which though useful in a mineralogical sense, had led to much confusion in geological classification, by its having been applied to formations of very different age. After the description of the other tracts of the south of Scotland, the historian says*—"Above Gallowaie is Carrike, sometime a portion of the region of the Silures. . . . Silurie is divided into 3 parts; to wit Carrike, Kile, and Cunningham." Then describing Carrike with its noble city, strong castles, and fair kine, and Kile, so called from Coile, King of the Britons, with its huge "deafe stone" north of Ayr, and its lake and river of Doon, he concludes with Cunningham as the "third part of Silurie, whose inhabitants in times past were most noisome to the Romans." It is the Carrick of this Silurian region that forms the first subject of our consideration. We shall then pass on to Galloway, including the counties of Wigton and Kircudbright, parts of which constitute the Southern division of the Siluria of early Scottish history.

A. Silurian and Carboniferous Rocks near Girvan, Ayrshire†.

The most fossiliferous Silurian Rocks yet discovered in Scotland lie directly to the east of Ailsa Crag, and to the north and south of the port of Girvan. Whilst these strata rise into hills on both banks of the Girvan Water, the intervening lower grounds in which that stream meanders are composed of carboniferous deposits which extend from the well-known extensive masses of the same age in the northern parts of Ayrshire, and here constitute a narrow and broken trough, the major axis of which is nearly parallel to the prevailing strike of the older flanking rocks‡. If the fossil remains of the carboniferous system had not been long ago distinguished from those of the Silurian æra, a geologist, judging from rude physical features only, might on a cursory view be led to suppose, that the coal-bearing strata dipped under the older rocks and were really intercalated in them. A brief inspection, however, of the ground, independently of any fossil evidence, would soon convince him, that although at a lower level and in some instances apparently dipping under the adjacent Silurian rocks, the carboniferous strata are wholly unconnected with them, and have been thrown unconformably against them by a great fracture, as represented in the annexed diagram. (See Map, Pl. XI. and Section, fig. 1.)

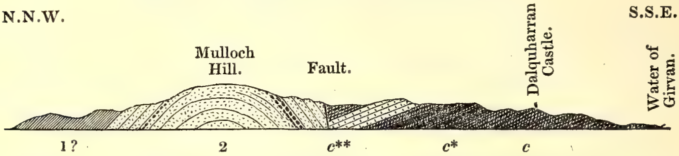
* See Hollinshed's Chronicles, Edition 1808, vol. v. p. 5. "The description of Scotland, written at the first by Hector Boetius in Latine."

† The accompanying map (Pl. XI.) is not offered as being correct in the boundaries of the formations, but simply as an approximation to assist the reader. The geography is taken from Mr. Keith Johnstone's Map of Ayrshire.

‡ See Map, *c*, Carboniferous.

Although I have no intention to describe these coal strata in detail, I may still say a few words on some of their dominant features which have not yet been developed. The diagram (fig. 1) expresses

Fig. 1.—*Section across Mulloch Hill.*



c. Carboniferous strata. *c**. Coal-beds. *c***. Carboniferous limestone.
1. Trilobite shale = Orthoceratite flags ? No. 1. fig. 2.
2. Shelly sandstone with some pebble beds.

the fact, that on the right bank of the Girvan Water, and particularly near the Home of Dalquharran, opposite to New Daily, light-coloured carboniferous sandstones (*c*) prevail. These form, in my opinion, the upper division of a very thick sandstone series, the lower parts of which are of a red colour, and rise up in undulations at Maybole, in the interior, and form the coast ledges that are well exposed at low water between Girvan and Turnberry Castle*.

In the valley of the Girvan Water, the yellowish and light-coloured sandstones have been irregularly broken up upon an anticlinal line trending from E.N.E. to W.S.W., and the beds having been tilted off to the N. as well as to the S. (see also fig. 2, p. 147), abut against the Silurian rocks, from which they are separated by a powerful line of fault. On the north side of the valley, and above Dalquharran Home, the coal-bearing strata (fig. 1, *c**) consist of sandstone and shale dipping 25° to the N.N.W. and enclosing four seams of coal, which have recently been laid open by galleries driven along the incline, and exposing many impressions of characteristic plants. In the upper or eastern portion of the valley, near Lammy Lane, courses of concretionary red and white mottled limestones are intercalated in this series, and are extracted for use ; and, although we detected no organic remains in them, it was manifest to us, that they were lithologically quite distinct from certain limestones of Silurian age hereafter to be described. Fortunately, since the visit of my friend and self, the successful fossil-collector of Girvan, Mr. Alexander MacCallum, of whom I shall have occasion to speak in the sequel, has forwarded to me organic remains which he has detected in courses of this bastard carboniferous limestone and shale (see Map) which clearly overlie the coal-bearing strata

* It is much to be desired that a competent geologist would endeavour to define what is really the base of the sandstones to which the term 'carboniferous' ought to be restricted in the South of Scotland. The red sandstones here adverted to are designated 'Old Red' in MacCulloch's map, and are therein confounded with the Silurian rocks about to be described! The distinctions of the Old Red Sandstone (Devonian) have been so ably and clearly delineated in the North Highlands, through their fossil distinctions established by Mr. Hugh Miller and Prof. Agassiz, that the discovery of any of those types in Ayrshire would at once reveal to us whether any portion of this Red Sandstone should be classed as Upper Old Red, or whether, as I am disposed to think, it is all of the lower carboniferous age.

ERRATA

In the Memoir of Sir R. I. Murchison on the Silurian Rocks of the South of Scotland—

Page 143, line 25 from the bottom, *for* (1) limestone and schists, *read* (1) flagstone and schists.

And in the description of Woodcut fig. 3. page 149, *for* 2. Shelly limestones, *read* 2. Shelly sandstones.

Quart. Journ. Geol. Soc. vol. vii.—To face page 143.

of Dalquharran, and are seen between them and the foot of Mulloch Hill, as represented in the diagram fig. 1 (c^{**}). These fossils are, *Productus giganteus*, Sow., *P. Martini*, Sow., *Nautilus tuberculatus*, Sow., *Spirifer*, probably *S. trigonalis*, Sow., and a Coral.

By such clear proofs we now clearly know, that the Girvan Water coal lies low in the carboniferous system ; since it is inferior to bands of limestone charged with unequivocal mountain limestone species. These coal beds have thus the same position as the chief carboniferous masses of Berwickshire and many parts of the south and centre of Scotland, as well as those of Russia and other countries, so clearly distinguished from the main coal-fields of England, which are superposed to the marine formation of that æra, or the lowest carboniferous division.

The sections figs. 1 & 2 will lead the reader to see, that the coal strata of the Girvan Water Valley have been subjected to very great dislocations subsequent to their deposition in a trough of those Silurian Rocks which I now proceed to consider.

Silurian ridges on the right bank of the Girvan Water.—Although the Silurian rocks are best exposed on the S. bank of the Girvan, where the hills are higher, and where some of the strata are seen in scars along the shore, I will first describe the hills N. of the Girvan, as I desire to carry the reader with me in an examination of the strata from north to south.

The rocks constituting the Silurian series of Ayrshire consist of (3) schists and limestones, (2) shelly greywacke sandstone with conglomerates, and (1) limestone and schists; and in the sequel it will be indicated that such is the ascending order of the deposits (see Table on the Map).

These ridges are composed of strata which strike from W.S.W. to E.N.E., or parallel to the general direction of the Silurian rocks of the S. of Scotland. The Girvan Water and the Stinchar (of which hereafter) flow in longitudinal depressions or fissures which are also coincident with the strike of the rocks.

The dominant rock in these low hills is a sandstone, in some parts of a grey, in others of a reddish, iron-shot colour, which abounds in shells and casts of shells. Whether its fossils or the lithological character of the rock be regarded, I did not doubt, on a first inspection, that it represented the Caradoc sandstone; for many of the rock-specimens from Ayrshire might be labelled Ankerdine Hill, or May Hill; places where that formation, as described by myself, assumes a clear and typical aspect in the original Silurian region. On the slopes of Mulloch Hill, above Dalquharran, this shelly sandstone dips sharply to the S.S.E. in several quarries which have been opened; but in passing over that low eminence the strata are seen to turn and dip also to the N. and W. The open quarries above the Rough Neuk, High Mains, &c., exhibit this shelly sandstone dipping 40° to the S.S.E. The prolongation of this dip of the older rock must therefore cut off the coal. In truth, however, there is every reason to suppose that some of the space between the carboniferous and Silurian rocks is occupied by an igneous rock ;

points of which protrude a little to the N.E. of this locality. Here the Silurian strata consist of very fine-grained, slightly micaceous, dark-grey sandstone, separated by thin wayboards of greenish shale. Fossils abound, and for the most part their shells are so well preserved, that great was my astonishment when I cast my eye over the surfaces of this rock and thought of the long time which had elapsed before such unequivocal and really beautiful Silurian types had been made known in Scotland.

Among the fossils, the *Atrypa hemisphærica*, Sow. (Sil. Syst.), is most abundant, and is associated with the *Orthis elegantula*, Dalm. (*canalis*, Sow., Sil. Syst.), *O. reversa*, Salter, and *Strophomena pecten*, Dalm. Of *Trilobites* there is a large, but imperfect *Illænus*, the *Phacops Stokesii* (*P. macrophthalma* of Sil. Syst.), and small fragments of *Calymene Blumenbachii*; an *Orthoceratite* with very close septa; *Turritella obsoleta* (Sil. Syst.), *Bellerophon dilatatus* (Sil. Syst.), *Murchisonia*, *Turbo*, and a *Trochus* (*T. Moorei*, M'Coy). There are two species of *Encrinites*, and several forms of Corals, including the *Petraia* (or *Turbinolopsis*) *subduplicata*, M'Coy, *P. æquisulcata*, M'Coy, and perhaps *P. elongata*, Phill., so abundant in the Lower Silurian rocks of Caermarthenshire and other places, together with the well-known *Porites pyriformis*, Lonsd.*, *Favosites alveolaris* or *Gothlandicus*, Sil. Syst., and *Ptilodictya* (*Stictopora*) *acuta*, Hall. There is also a singular unpublished body (Pl. IX. figs. 16, 17), which Mr. Salter, to whom I referred all my collection, recognises as identical with a fossil of the Llandeilo flags of Robeston Wathen in Pembrokeshire, and which may either be the flattened *nidus* or egg-capsules of a Gasteropod, or a new form of *Bryozoon*.

In the continuation of this line of low hills at Lower Thrave, Snaid, &c., this shelly sandstone has usually an ochreous red colour, containing the *Lichas laxatus*, M'Coy, which is common in the Llandeilo limestone of South Wales, in its equivalent the Bala limestone of North Wales, and in Ireland; together with *Atrypa hemisphærica*, Sow., var., *Hemithyris angustifrons*, M'Coy, *Orthis reversa*, Salter, *O. biforatus*, Schloth., *Phacops Stokesii*, common in May Hill, Gloucestershire, and the *Terebratula cuneata*, Dalm. The presence of this last-mentioned Wenlock fossil, which has not yet been found in the Lower Silurian rocks of England, coupled with other fossils which usually pertain to higher members of the series, including the *Phacops Stokesii* of Dudley, might lead one to suppose that these shelly sandstones are, as a whole, the upper part of the Lower Silurian rocks. On the other hand, some of the forms point clearly to the horizon of Llandeilo, a position to which Mr. Salter would rather refer them.

In crossing the Mulloch Hill to the N. and by W., the above-mentioned sandstones are seen to graduate downwards into partial conglomerates, in which fragments of red granite, limestone, and other rocks occur, and the whole, then folding over in gentle undu-

* This fossil, it would appear, must change its name; Mr. Dana proposes to restore Guettard's old name *Heliolites* for the genus, and Wahlenberg's specific name *interstinctus* might stand for the species, or more properly still *subrotundus* of Fougt. Prof. M'Coy proposes the name *Palæopora* for the genus.—J. W. S.

lations, exposes masses of highly ferruginous and reddish sandstone, in which we detected portions of the *Calymene Blumenbachii* or "Dudley fossil" of old writers.

This fossil becomes, indeed, abundant in certain schists or mudstones (1) which seemed to me to overlie the mass of the shelly sandstone and conglomerates. These schists occupy the low slopes of a depression to the east of the farm of Drummuck, and at all events form a flanking part of the same range as the sandstones. As the adjacent shelly sandstones undulate, they appeared to me to trough this Trilobite-shale. Seeing that they contain the true *Calymene Blumenbachii* (as identified by Barrande and other naturalists) as well as the *Cheirurus* (*Paradoxides*) *bimucronatus* (Sil. Syst.), I am, I confess, disposed to think, that if pertaining to the Lower Silurian division, these soft schists (1) lie in the upper zone of its Scottish development. I know, indeed, that these species of *Trilobites* are no longer exact chronometers of the age of the strata, and are almost universally 'Silurian,' one of them being found from the Ludlow rocks even down, as I am now assured, to the slates of Snowdon! But here they are unquestionably associated with rocks which, although chiefly of the Lower Silurian age, show signs in their fossils of an ascending order. When followed in their strike to the W.S.W. or to the sea-shore, these strata of shelly sandstone are entirely denuded, and are unconformably overlaid by the carboniferous? red sandstone above spoken of, which forms ledges on the beach (*c* of Map).

A great mass of limestone at Craig Head, on the N. bank of the Girvan Water, still remains to be assigned to its geological place (see Map). The chief difficulty in doing so arises from the fact, that large masses of amorphous greenstone and amygdaloidal trap flank it on the S.W. and N., and thus cut it off from the strata above described. No Silurian strata are there visible, towards the carboniferous valley of the Girvan, or eastwards; whilst the signs of bedding in the limestone are almost obliterated.

This limestone is laid open by quarries from 60 to 70 feet deep, and occupies the lower portion of undulating hills which consist, in this higher part, of trappean amygdaloid and greenstone. The rock is of a grey colour, chiefly amorphous, with irregularly intercalated portions of greenish earth. The limestone is white-veined, and presents, even at first sight, the aspect of being of Silurian age. Although I only detected imperfect traces of fossils, Mr. J. Carrick Moore has obtained quite a sufficient number, not till now announced, to lead us to affirm that the rock is unquestionably Lower Silurian, and of the same age as other limestones hereafter to be described. These fossils having been examined by Mr. Salter, prove to be—

Orthis elegantula, *Dalm.*
Orthis confinis, *Salter*, Pl. VIII. fig. 5.
Orthis, n. sp.
Leptæna or Strophomena, 1 or 2 species.
Terebratula, an obscure species, Pl. VIII. fig. 3.
Pleurorhynchus dipterus, *Salter*, Pl. VIII. fig. 6.

Cheirurus (Amphion) gelasinosus, *Portlock*, sp., Pl. VIII. fig. 1.
Heliolites (Palæopora) favosus, *M'Coy*.
Favosites alveolaris, *Blainv*. sp.
Petraia (Turbinolopsis) elongata, *Phill*. sp.?
Encrinites, &c.

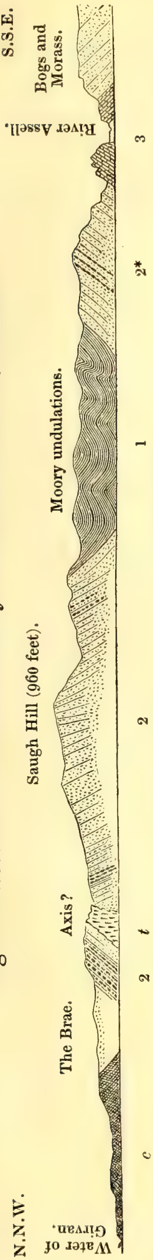
Coupling these and the *Maclurea macromphala*, M'Coy, found also by Professor Sedgwick in this quarry, with the large *Illænus* in the adjacent sandstone of Mulloch Hill, there can be no doubt that both these rocks belong to the same zoological group of the Lower Silurian rocks. At one end this rock is flanked by a coarse pebbly conglomerate, and this again by schist. The latter is cut through by a magnificent dyke of greenstone, which has been extracted for the use of the roads, leaving the indurated schist as walls on either side of a profound and slightly tortuous channel of about 60 feet deep, 150 feet long, and 12 feet wide.

I could not look at the mineral character of this mass of limestone, nor at its association with pebble beds and trap rocks, and not have the analogy of the Nash Scar and old Radnor limestones of the Silurian region forcibly brought to mind; and, if the above-mentioned fossils had not been found, the two rocks might have been rudely assimilated. For my own part, however, the more I have seen of the rocks of this age in other countries distant from each other (and even in the Silurian region I showed the evanescence of the test), the less I am disposed to adhere minutely to divisionary lines, as marked by any courses of concretionary limestone. Judging from fossils and the analogy of other parts of this tract, it is indeed almost certain that this limestone of Craig Head lies low in the Scottish Silurian rocks, and is here upcast through the shelly sandstone. It is, I have no doubt, the equivalent of other limestones, which, as I shall presently show, have been raised up on other anticlinals further southwards. On the whole, then, there is no doubt that the ridge on the north bank of the Girvan marks the anticlinal No. 1 of the map.

Saugh Hill Section.—To the south of Girvan Water the Silurian rocks rise, as before said, into loftier eminences, of which Saugh Hill, nearly 1000 feet above the sea, and immediately to the east of the town of Girvan, is the most prominent. Having made a transverse section of the strata about three miles inland, and another oblique section where the ends of some of them are exposed at low water to the S. of Girvan, I shall be enabled to show the grounds for the conclusions at which I have arrived.

In ascending from the carboniferous trough about a mile and a half E.N.E. of Girvan, there is first seen a yellowish sandstone which dips 45° S., and thus seems to plunge under the whole mass of Saugh Hill. But this sandstone, in which there is no trace of fossils, is evidently referable to the carboniferous group (*c*). The Girvan Water indicates, as before said, the axial line of a valley, from which the carboniferous strata have been thrown off to the south on this side, as they are to the north on the opposite side of the depression above Dal-

Fig. 2.—*Section across the Strike of the Silurian Rocks* ($3\frac{1}{2}$ miles).



c. Coal formation. *t.* Eruptive rocks.

Silurian rocks in descending order,— 2. Shelly sandstone with pebble beds. 2*. Greywacke sandstone with coarser conglomerates. } Shelly sandstone. 3. Axis of limestone and schist.

1. Orthoceratite flags = Trilobite flags? No. 1. fig. 1.

quharran (fig. 1). Mounting over the slope for some little space which is obscured by vegetation, fragments of finely laminated schist are next observed to be associated with coarse gritty greywacke. Presently the knobby summit of the Brae is seen to consist of a conglomerate (No. 2), containing pebbles of quartz-rock and jasper, which is underlaid by flaggy sandstone, the whole being tilted off to the north by a boss of greenstone. This conglomerate has no distinct relations to the Silurian strata of Saugh Hill, nor does it resemble in lithological composition a very coarse conglomerate which will afterwards be described as occurring at Kennedy's Pass. I am, however, of opinion that it is of Silurian age, because somewhat similar pebble-beds are found in the shelly sandstone of Saugh Hill with a reversed dip. In describing the coast section (fig. 3), it will also afterwards be shown that such conglomerates to the south of Shalloch are intimately associated with true Silurian strata.

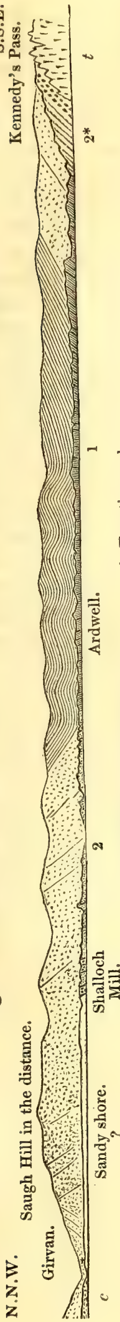
A zone of marshy land here indicates a line of dislocation which probably constitutes another axial line. Some of the lowest beds of the north-western face of this hill, as exposed in a deep gully, are finely micaceous schists, occasionally containing crystals of iron-pyrites. These again are followed by shelly sandstones and here and there a bastard limestone, with a few pebbles in some of the beds, in which fossils occur in quarries opened out to the eastward for the construction of stone walls. The strike of these beds is persistently from E.N.E. and W.S.W. Many of the fossils are the same as those on the north bank of the Girvan; but, in addition to *Atrypa hemisphærica*, Sow., and other characteristic Lower Silurian forms, we here detect the *Tentaculites ornatus* and the *Pentamerus oblongus* of the 'Silurian System.'

Near the highest point of Saugh Hill the strata are very highly inclined, viz. 80° to the S.S.E., and even on the escarpment side they dip as high as 65° to 70°, but with an inclination always southerly; and thus a great thickness of strata is evidently contained in this one hill. In gradually descending from it, and continuing in a true transverse section to the S.S.E. across the lower hills, further inland, other strata of finely micaceous, greywacke flagstones continue to dip in the same direction, but at the lesser angle of about 45°. Then comes another quartzose pebble and conglomerate bed of no great thickness, followed by a greenish coarse-grained sandstone. The next overlying strata are dark flagstones with a bluish or purple coloured exterior and containing minute fragments of fossils. These beds are, it seemed to me, a part of the orthoceratite and graptolite division (1), of which hereafter; for in an undulating and moory country like this, where the strata are only visible at intervals, it would be unsafe to estimate exactly the ascending series if we had not other proofs. In advancing to Tor Mitchel, where a very large mass of limestone is quarried and exposed on the right bank of the Assell stream, we found, however, an intermediate range of sandstone and pebbly conglomerate, exposed at the farm of Birbals, with a dip reversed to the N.N.W.; and when, in making afterwards a section on the adjacent coast, I there found the conglomerates of Kennedy's Pass also dipping to the N.N.W., I drew the inference that the deposits were arranged in a trough, of which the black schists and flagstones (1) form the upper or central part*. Here, then, we were manifestly approaching another line of dislocation, of which we had the proofs on reaching the limestone of Tor Mitchel. The physical evidence clearly indicates that this limestone is on a line of axial disturbance, and is older than any stratum described in the Saugh Hill section. The chief mass of this rock is of dark grey colour with white veins, and is cut into for a depth of about fifty feet, but it is so amorphous and isolated, that it shows few clear relations to the before-named strata, except that it seems to rise out from beneath them. At its eastern extremity, however, bedding sets on, and a small nodular structure, very much like that of many well-known Silurian rocks, becomes apparent; the whole decidedly plunging S. and by E. Again, the other bank of the Assell brook is seen to be also made up of a portion of this limestone, which is there both thin-bedded and concretionary, and which, striking from E.N.E. to W.S.W., dips unequivocally to the S.S.E. under massive undulations of schists, conglomerates, &c. &c.

The Tor Mitchel limestone marks therefore a third axial line, along which the limestone is traceable to the E.N.E., whilst to the W.S.W. the upheaval is connected with the protrusion of great eruptive masses of rock, of which hereafter; and I have no doubt that this limestone is of the same age as the fossiliferous rocks of Craig Head, and of limestones on the more southern parallels, at Aldeans, Bogang, and Craig Neil, which from their imbedded remains, as well as from their position, are considered to be the oldest fossiliferous rocks of the region. (See Map.)

* Mr. J. Carrick Moore has informed me since these pages were written, that he also found the strata, including pebbly beds and impure limestone, reversed with a northerly dip on the hill-road from Girvan to Barr; and he is of the same opinion as myself, that the orthoceratite flags lie in a trough, as represented in figs. 2 and 3.

Fig. 3.—Coast Section,—oblique to the Strike of the Silurian Rocks.



c. Carboniferous sandstones. t. Eruptive rocks.

Silurian rocks in descending order,— 2. Shelly limestones with pebble beds. } Shelly limestone. ? Sandy open shore. Place of shelly sandstone. The strata are here denuded on the true strike. The inland banks are covered with drift.
2*. Conglomerates.
1. Orthoceratite flags.

The coast formed by the denuded, upcast strata of the shelly sandstone and flags is rocky and dangerous; the hollows in the Silurian rocks contain large boulders of granite, &c., part of the general drift.

In the meantime, with reference to the Saugh Hill section (fig. 2), it may be noted, that in some of the courses of its sandstone there occurs a band so shelly as almost to be called a bastard limestone, in which the *Pentamerus oblongus* is abundant. This shell is associated with *Tentaculites ornatus*, Sow., *Atrypa hemisphærica*, Sow., and *Terebratula serrata*, M'Coy. I attach importance to the abundant presence of the *Pentamerus oblongus*, Sow., in association with *Phacops Stokesii*, *Tentaculites*, and other types, as marking, in Saugh Hill, an upper portion of the Lower Silurian rocks. For, although I have been informed by Mr. Salter and the Government geological surveyors, that they have also found abundantly the *Pentamerus oblongus* deep in the Lower Silurian, still I am of opinion that its most usual position (certainly the *Phacops Stokesii* belongs to an upper stratum) is as above stated. I therefore hold, that in this transverse section across Saugh Hill (fig. 2), the Lower Silurian rocks with fossils (2) indicate an ascending series, and form the sides of a trough on which orthoceratite flagstones (1) repose. Other proofs of this order follow.

Conglomerates, Orthoceratite Flagstones, and Graptolite Schists of the Coast Section south of Girvan.—Turning from the inland transverse section just described, to the coast, the geologist, who knows how rarely he can trace the true Silurian order in any sea-cliffs and ledges of the British Isles, is not altogether disappointed. But unluckily, in commencing the section from Girvan, and in proceeding southwards, he meets with no trace of the shelly sandstones, so abounding in fossils in Saugh Hill and particularly on its northern slopes. They are all denuded. In following the strike of these beds from Saugh Hill until we reach the coast, they are there found to be rounded off and obscured; and all the shore in which, according to their strike, they ought to appear, is simply a sandy beach (see fig. 3). This may be accounted for by the fact, that these shelly sandstones, where they are not in the vicinity of igneous rocks (none of which occur between Saugh Hill and Girvan harbour), are more destructible than the hard greywacke-conglomerate and flagstones which are now to be treated of. On the beach at low-water and to the south of this denudation, ledges of conglomerate, flagstone, and schist are plainly exposed, between the hamlet of Shalloch and the house of Ardwell. Courses of reddish conglomerate are first seen at Shalloch Mill, nearly two miles south of Girvan Water (see fig. 3), in which white quartz pebbles abound, varying in size from a child's head to that of the fist and large playing-marbles. The rock is much broken up and disturbed, and the greywacke-slate, contorted and twisted up like gneiss, is dovetailed between bosses of the pudding-stone; some idea of which may be formed from fig. 4. To the south of Shalloch Mill the greywacke-flagstones are vertical and strike 20° N. of E., and in this band of conglomerate are broken fragments of an older greywacke than that with which it is associated. Then follows a succession of vertical flagstones, somewhat dislocated, and after them another band of conglomerate, the contents of which are rather more brecciated and angular. This conglomerate, replete also with white quartz pebbles, is different from one to be presently described, and is apparently of about the same character as the conglomerate-band above noted in the Saugh Hill section (fig. 2). It runs out in a bold scar called Kellie Rock, visible at low-water, and exhibits the most perfect passage into, and conformity with, the greywacke-flagstone and schists.

Fig. 4.—*Appearance of the Conglomerate and Greywacke at Shalloch Mill.*

2* 2

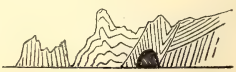
2*. Conglomerate or Haggis-stone.
2. Greywacke.

These latter beds are exhibited at intervals all along the shore, and as you advance to Kennedy's Pass, they are not only traceable at low-water, but jut out upon a grassy flat between the hills and the shore, like the tombstones of a closely tenanted churchyard, all perfectly parallel to each other, and all having the chief strike of this Silurian tract, viz. from E.N.E. to W.S.W. Here and there they are cut through by trap-dykes: occasionally the line of strike is distorted, and, as they approach the powerful conglomerates and trap-rocks of Byne Hill and Kennedy's Pass, they offer many curvatures and fractures, some of which are represented in figs. 4, 5, and 6.

Figs. 5 & 6.—*Appearance of the Greywacke Flagstone North of Kennedy's Pass.*

Fig. 5.

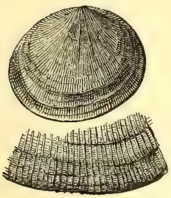
Fig. 6.



It is in the central portion of these strata (1), both in flagstones and in geodes, either of a slightly calcareous black schist, or in parts an earthy limestone, that Alexander MacCallum has found at various places, both on the coast and in the interior, a very large species of *Orthoceratites*, together with other forms of that genus, a *Cyrtoceras*, and one or two species of *Graptolites*, and some flattened Brachiopods, including *Orbicula*. The large species of Orthoceratite being unknown to myself, and not being identifiable with any published species, I referred it to my friend M. Barrande (then on a visit to our country), and he recognized it to be one of the Bohemian species, occurring in the lower part of his Upper Silurian division*.

Now, in Bohemia this very species of Orthoceratite occupies the same place as the greater number of species of *Graptolites, i. e.* the schists and flags at the base of the Upper Silurian rocks; and it is further remarkable that there also it lies in schists and nodules of hard impure limestone so like those of Ayrshire, that on inspecting them M. Barrande declared to me he might even produce our Scottish rocks as Bohemian specimens. Such is also the position of the greater number of the *Orthoceratites* in the original Silurian region of England; and of the species which specially characterize the Upper division we find here the *O. virgatum* (Sil. Syst.), a form to which allusion will hereafter be made as occurring at Balmae Head in Kircudbright. On the other hand, in those Scottish rocks I observed one Orthoceratite with a lateral siphon which it is difficult to separate from the large *O. vaginatum* of Scandinavia and Russia, which I have described as characteristic of the Lower Silurian†. In addition to one or two other species of Orthoceratite, whose specific character cannot be defined in the absence of their shelly covering, MacCallum has procured from the same group a few specimens of *Cyrtoceras* which much resemble forms characteristic of the Upper Silurian rocks of England; with these is found (usually much flattened) a thin, finely striated *Orbicula*, like *O. striata* of the Ludlow rocks (see fig. 7). The question then occurs, is this zone of the same age as that of Bohemia in which M. Barrande has collected above 200 species of *Cephalopoda*, including *Orthoceratites, Phragmoceras, Cyrtoceras, Gomphoceras*, and a multitude of *Graptolites*; the whole there occurring, as I can indeed myself testify, in rocks undistinguishable from those now under consideration? The *Graptolites* in these beds, having been examined by M. Barrande and Mr. Salter, prove to be a double-graptolite very like *G. pristis*, Hall, a species nearly allied to *G. colonus*, Barr., and *G. tenuis*, Portl. Judging from this group of fossils alone, I should (independently of the proofs of succession) be disposed to consider those orthoceratite-flags and graptolite-schists of Piedmont, Ardwell, and Penwhapple Burn, as superior

Fig. 7.



Orbicula? crassa, Hall.

* Professor McCoy has, I find, lately published this species under the name of *O. politum*; but as this memoir is intended to be useful in leading Scotch geologists to be acquainted with the chief types of their oldest fossiliferous rocks, this Orthoceratite is here figured, although it will probably be also given in a work on the Palæozoic Rocks now in course of preparation by Professor Sedgwick.

† See Russia in Europe, vol. i. chap. 2.

to the great mass of the shelly sandstones of Saugh Hill, Mulloch Hill, &c.

If I were to draw my inferences either from the original Silurian region or from the Bohemian development of rocks of the same age, I should not have hesitated to place these flagstones in the lower part of the Upper Silurian division. But here again, as in relation to other fossils already alluded to, I am reminded that forms of the genus *Cyrtoceras* have also been found by the Government geologists very deep in the Lower Silurian; thus linking the whole series together by a community of zoological types.

Not relying, therefore, on such fossil evidences for a point of detail, which after all is of no great import, we have still, I think, fair evidences of superposition. From Shalloch Mill to Ardwell and Ardmillan (see fig. 3), the strata are either vertical or so slightly inclined to the S.S.E. that I came to the conclusion, that just as the last visible pebble-bed in the Saugh Hill ascending section dipped S.S.E. and thus seemed to pass under flagstones, so do the Shalloch and 'Kellie Rock' scars (2) stand in the same relation to the orthoceratite-flagstones (1). It seemed to me unquestionable, that the very beds in which the *Orthoceratites* occurred on the shore, were by their strike traceable into Piedmont Glen, where they are seen in a highly inclined, broken condition, and in parts mineralized. In proceeding along the shore, these flagstones are also seen to be broken, dislocated, and incurvated in every possible manner, two examples of which I offer in figs. 5 and 6. Traversed here and there by small trap-dykes, these flagstones acquire, however, a steady dip to the N.N.W. as they approach the bold headlands of conglomerate and igneous rock which range down to the bluff coast from the grey hill of Ardmillan and Shill Hill. The rocks cut through in constructing the striking coast-road which leads from Girvan to Ballantrae consist, at the headland called Kennedy's Pass, of by far the finest example of coarse Silurian conglomerates which I have met with in any part of the world; and there they dip most unequivocally to the N.N.W. under the orthoceratite-flags and schists at an angle of 40°, as represented (2*) in fig. 3. This section coming, therefore, with a reversed dip in corroboration of that of Saugh Hill, my belief is, that the flagstones and schists occupy a dislocated, contorted, and broken trough, supported on the one side by the pebble-beds, conglomerates, and shelly sandstones of Saugh Hill, and their coast equivalents of Shalloch and Kellie Rock, and on the other by the coarser conglomerate of Ardmillan Hill and Kennedy's Pass on the coast, and by the limestone and schist (3, fig. 2) in the interior.

This spot must not, however, be quitted without a description of its very powerful and striking conglomerate. All the materials of this conglomerate are rounded and waterworn, and, according to Professor Jameson, some of the pebbles which he had seen many years ago seem to indent each other; an observation, I may remark, which agrees with one recently made by M. de Verneuil in examining the conglomerates of the Devonian or Old Red Sandstone age in the Cantabrian range of Spain. Professor Nicol and myself distinguished upwards of twenty varieties of rock among the pebbles, varying in dimensions from the size of musket bullets to two and three feet diameter. Among them are small specimens of earthy greywacke and larger ones of hard siliceous greywacke, Lydian stone, hornstone of various colours passing to porphyry, dark red jasper, red jaspidified felspar-rock, broken and re-cemented in the pudding-stone, granites both of red hornblendic and grey syenitic varieties, and also the protogine variety of that rock, grey porphyry with long acicular crystals of felspar, brown and red felspar-porphyry, occasionally with highly polished surfaces, porphyritic felspar-rock or Cornéen, greenstone, both common and porphyritic, &c. All these varied materials, none of which are like the old crystalline rocks of the Highlands, whilst some were even undistinguishable from igneous rocks which we know to be of posterior eruption to these very conglomerates, are cemented in a matrix of quartz and dark brownish clay (decomposed greywacke) with some scales of mica, fragments of hornblende, and occasional veins of fibrous calc-spar.

The conglomerate in this locality is several hundred feet thick, and, mounting up in sloping terraces on the shoulders of the trap-rocks, ranges, with some courses of intercalated sandstone, into the interior. Such conglomerates are also met with at various places inland; for we traversed one band in passing to Barr, a few miles distant from the coast. Seeing that various courses of conglomerate are subordinate to the shelly sandstones, and believing that the group supports the orthoceratite and graptolite schists which have been described, I cannot divest myself of the opinion, that the uppermost of these conglomerates (of which I believe there are several courses at various horizons in the sandstone of this region) is not far removed from the upper limit of the Lower Silurian rocks of Scotland. The analogy of the English Silurian rocks favours this view; for in them the pebbly conglomerates which are of most importance occur in certain districts, as at Presteign near Welshpool, towards the upper limits of the Lower Silurian. As in the Welsh examples, the most powerful of these Scottish Silurian conglomerates, or that of Kennedy's Pass, though on a much grander scale, is also but of local development, and the Bohemian section is also analogous: I shall, indeed, give a transverse section of all the Silurian strata in the heart of the South of Scotland, from the N. of Dumfriesshire to Balmae Head in Kircudbright, which exhibits no trace of such a rock.

Limestones and Schists (*with Trap Rocks*).—Let us now consider the character and relations of the limestones which appear at intervals in the more southern tract watered by the Stinchar River and its tributary the Assell. A very large portion of the coast from the conglomerate of Kennedy's Pass to Ballantrae is occupied by eruptive rocks, consisting of greenstone and porphyry, with much diallage rock and serpentine, some purple and spotted varieties of which reminded me of the serpentines of Coverack Cove in Cornwall. Metamorphic schists are also abundant. Occupying Bennan Head and extending to some distance inland, the intrusive rocks usurp, however, most of the surface, and separate the limestones of the Stinchar from the Silurian rocks of the Girvan district. One of the most striking of these eruptive hills, and in form not unlike Arthur's Seat near Edinburgh, is Knockdolian, on the right bank of the Stinchar, which throws off one shoulder to Colmonel and another to Ballantrae, whose old castle stands upon the rock. The lower and seaward slopes of this trappean mountain are covered with much drift, which there occupies terraces*. Geologists may, indeed, be surprised, when they throw their eye over MacCulloch's Geological Map of Scotland, and observe that whilst all the tract around Girvan, which has just been cited as so eminently Silurian by its fossils, is coloured as Old Red Sandstone; so in the district now under notice, not a vestige of igneous rock or limestone is indicated, the whole being laid down as greywacke or clay-slate! And yet the lofty, lichen-covered vertical cliffs of serpentine and greenstone, as exposed in the seaward faces of Bennan Head, form as pictorial a scene of igneous rocks as any in Scotland. It is in the eruptive rocks (chiefly serpentinous and diallagic), which throw off the conglomerate, that most of the caverns and chasms prevail; and, even as an admirer of fine scenery, I must regret that this grand coast section has not been sketched by a good artist and made known to the public.

Proceeding inland from the rugged headland of Bennan to its equally igneous neighbour Knockdolian, a limestone, first visited I believe by Mr. J. Carrick Moore, is seen to be worked at the farm of Bogang, not far distant from the north slopes of the latter. Although close to an eruptive mass, the strike of this limestone and shale is nearly that of the Silurian strata of the region, and the dip is to the south or towards the igneous rock. The chief mass of this limestone is of very dark colour with white veins, and soapy, serpentinous *sahlbandes*. The fossils chiefly occur in the alternating and underlying shale-courses, and the collection we made consisted of *Orthis virgata*, Sow., *O. confinis*, Salter, *Maclurea magna*, Hall ?, *Murchisonia*, and a fragment of a large *Isotelus*†. As the *Orthis virgata* occurs in the limestone of Peebleshire, and is there also associated with a species of *Isotelus*, it is fair to infer that this rock of Bogang, as well as that of Craig Head north of Girvan, is of the same age as the stratum described by Professor Nicol, which he has, I think, very properly referred to the age of the Llandeilo flags.

On the left hand of the Stinchar and opposite to the village of Colmonel, limestone has also been long quarried from under the old castle of Craig Neil, inhabited formerly by Nigel, the brother of King Robert Bruce. The rock, in which some fossils are visible, has there been thrown up into a conical hummock, and, from its altered, frac-

* The flat shore at Ballantrae also exposes nearly horizontal ledges of a very soft thick-bedded dark red sandstone (see Map), which is manifestly younger than the inclined red sandstone of this coast. Although I do not pretend to define its age with accuracy, I presume it must be classed with the newer Red Sandstone—a very loose term—of Dumfriesshire and Cumberland.

† Most of these fossils were first obtained by Mr. J. Carrick Moore. The collection made by Professor Sedgwick contains one or two other fossils. The *Maclurea* found here is a different species to that occurring at Aldeans, which we have figured in Pl. VIII. fig. 7.

tured, and distorted aspect, is probably affected by the trappean eruption to which Knockdolian Hill and the valley of the Stinchar owe their origin. At Aldeans quarries, about three miles N.E. of Colmonel, and in hills above the right bank of the Assell, the same limestone as that of the Bogang Farm and Craig Neil is quarried in dislocated masses. This dark-coloured rock, containing *Maclurea* and the same fossils as in the other localities, is in most parts either thick-bedded or amorphous, of a highly altered character, and very fetid under the hammer. As at Bogang, trap and serpentine protrude, and one fine specimen of *Maclurea* as well as the smaller fossils obtained are coated over with serpentinous matter. Here the rock has been wrenched, contorted, and partially deflected from the true strike; for at the east end of the quarries the beds farthest removed from the centre of disturbance, and which are laminated and nodular, dip 40° to the E. and by S., or away from the trappean eruptions.

It is worthy of remark, that parts of the surface of the limestone have been covered with a pebbly conglomerate, which, although it dips generally with the inferior limestone, seemed to me to overlap it with a slight unconformity, or at all events to have been deposited on the eroded surface of the limestone. This point of observation is not to be neglected by those who may hereafter be called upon to decipher more closely the features of this contorted region; for it might prove the existence of a dislocation in the South of Scotland, which may explain the occurrence of the very coarse conglomerates, and also lead to the identification of some of the sandstones with the true Caradoc, and of others with the sandstones and pebble-beds of Llandeilo age, delineated by Prof. Ramsay as lying unconformably beneath the Caradoc*. It occurred to me, therefore, that if the conglomerate of Kennedy's Pass be one of the highest in the district, this of Aldeans might be one of the lowest or oldest; since the fossils of these black limestones induce us to consider them as belonging to the most ancient recognizable Silurian band of this region. It is indeed manifest, that the whole of the series of the shelly sandstones of this district is diversified and swollen out by courses of conglomerate, which, however thick and powerful in one locality, thin out upon the strike and are not persistent in the general masses of the greywacke of the South of Scotland. The Silurian conglomerates of Scotland, therefore, are to be viewed as phænomena of much more local character than those of the Old Red Sandstone.

In regard to the chief limestones, I believe that they are all of the same geological age, and that, together with the schists associated with, and beneath them, they form the lowest band of the Lower Silurian group of Ayrshire†. The species of *Orthidæ* and the Trilobites they

* See Journ. Geol. Soc. vol. iv. p. 296.

† The presence of a form of *Maclurea* would not in itself be sufficient evidence, the genus having been found in rocks of Devonian age at the Rittberg, two German miles S.W. of Olmutz in Moravia, by M. de Verneuil, Count Keyserling, and myself. We there found it with an abundance of Devonian fossils in deep-coloured limestones overlying other rocks more or less metamorphosed which are probably of Silurian age (see Jameson's Phil. Journ. Edin. 1847, vol. xliv. p. 77).

contain are indeed sufficient to settle this point, whilst the *Maclurea* is a good Lower Silurian type in North America.

Looking at the tract in which these insulated masses of limestone occur as one of powerful eruption, it is natural indeed we should find still older rocks brought to day than any which are visible in the tracts on the banks of the Girvan Water, where the igneous rocks are much less rife. The limestones of the Stinchar are, therefore, to be considered simply as insulated masses of Lower Silurian, which have been forced into their positions along sharp anticlinals, assisted by the action of the copious igneous rocks; which have disjointed them from the conglomerates, sandstones, and schists of the Girvan district. It is fair, therefore, to infer, that the protrusion of these limestones with their underlying schists marks two other sharp undulations or anticlinal lines. Thus, in prolonging the strike of the Bogang rock, it is found to be coincident with the Aldeans quarry and the whole course of the Upper Stinchar above its junction with the Assell; whilst the anticlinal of the Craig Neil limestone coincides with the course of the Lower Stinchar from Pinwhirry Castle to the sea (see Map).

The occurrence of five or six axial lines in a traverse of less than eight miles directly across the strata is an important feature which will be afterwards dwelt upon. In the mean time, it may be said, that the Ayrshire Silurians contain evidences both zoological and stratigraphical (the one method helping us where the other fails), to show that some of their strata are of the age of the Llandeilo or Bala limestone, whilst others, including the conglomerates, belong to strata extending upwards to the zone of the Caradoc sandstone. Whether the orthoceratite schists and flagstones will also be classed with the Lower Silurian, or form the base of the Upper Silurian rocks, must be a subject of future discussion; although it is manifest that all these subdivisions here form one natural group only.

The only point of detail on which my associate, Professor Nicol, entertains a different opinion to that which I have suggested, is that he surmises that the shelly sandstones (2) of Saugh Hill may overlie the orthoceratite-flags (1). He grounds his view on the impression which he has taken of the physical structure of this much-obscured tract, and, as he was disposed to think that ulterior researches might establish his view, I presented his two ideal sections of the coast and the interior to the Geological Society. I cannot, however, admit the possibility of separating the conglomerate from the shelly sandstones; because in this very tract of Scotland I saw pebble-beds intercalated and repeated in that, which from its fossils I consider to be the equivalents of the Caradoc or Llandeilo sandstones, passing down into limestone of the age of Llandeilo and Bala; in one spot forming courses immediately above the lower limestone, in another recurring at different horizons in the ascending order, until they form, as at Kennedy's Pass, the very remarkable mass which supports the flagstones and schists with *Orthoceratites* and *Graptolites*.

B. Schistose Rocks ranging through Wigtonshire and Galloway to Kircudbright.

It would be presumptuous in any one who, like myself, merely made one transverse section of them, to pretend to define the precise relative age of the schists of Wigtonshire which succeed on the south to those of Ayrshire. Mr. J. Carrick Moore and Mr. Salter have already described some of their *Graptolites**, and Professor Sedgwick has visited the localities and is better acquainted with them than myself.

Referring, however, to the opinion already expressed, that the limestones and associated strata of the Stinchar are the oldest rocks of the tract, and also that the portion of them in which any stratification is visible dips southward, it might be suggested, that the schists of Wigtonshire, in which the *Graptolites* occur, may possibly lie above them; but I have formed no decisive opinion on this point.

To the south of Ballantrae all sequence of the stratified masses is again cut off by a large development of igneous rocks, which form the chief eastern headland of the mouth of Loch Ryan. We have thus ample space for another great axis and repetition of shelly sandstones, &c. Mr. J. Carrick Moore has, indeed, it seems to me, done much to indicate an equivalent of such by having found, as he has recently informed me, masses of vertical conglomerate very similar to those of Kennedy's Pass at the point of the headland of Finnart and to the south of all the trappean cliffs. This conglomerate, therefore, when prolonged upon the strike, lies in an intermediate position; the great trappean and limestone region being on the north, the Wigtonshire schists on the south. Little evidence is obtained on the sides of the high road which passes inland by Glenap Lodge†, and owing to intrusive bosses of trap the strata are in great disturbance and undulation. As soon as we pass over undulations of worthless greywacke-sandstone, which is exhibited in a rude anticlinal, this tract is seen to consist almost exclusively of schists, on the whole much resembling the 'rotch' and mudstone of S. Wales. In a rough, rocky glen, which leads down to the valley of the Finnart, the rocks present all that irregularity or confusion of stratification so prevalent in the schists and 'rotch' of S. Wales, with numerous imperfect cleavages; but after some rude undulations, acquiring more of a flagstone character, the beds pitch southwards at a high angle, and thus conduct the observer to the well-known slate-quarries of Cairn Ryan. There, as Mr. J. Carrick Moore has shown, *Graptolites* both foliaceous and simple abound. There are no slates (at least none that Professor Sedgwick would admit to be such) in the quarries of Cairn Ryan; but those used for roofing are simply finely laminated flagstones. The surfaces of the beds have here and there a most remarkable polish, and are farther remarkable in exposing *Graptolites* spread along the laminæ of deposit. Some of the surfaces of the beds have even a slightly rippled surface, and curvatures occur here and there.

* *Loc. cit.* p. 15, 16, Pl. 1.

† The seat of the Earl of Orkney.

To what extent the strata of this formation may undulate or be repeated, from the parallel of Stranraer towards the bay of Luce on the south, I had no means of determining. The country so declines in altitude, and its outlines are so rounded off, that, except in the sea-cliffs of the Mull of Galloway, little can, I apprehend, be learned. There, I am informed by Mr. J. Carrick Moore, some reversed dips occur, together with igneous rocks.

Having passed by Glen Luce, however, and thence eastwards by Newton Stewart, across the granitic region of Cairn's Muir, Prof. Nicol and myself then traversed the whole series by proceeding from New Galloway to Castle Douglas and Kircudbright and Balmae Head. In that section we were satisfied, that the same strata were repeated, both in numerous undulations and also by longitudinal faults. Thus, the larger portion of Galloway, wherever granite and porphyry do not intrude, presents a monotony of outline which is essentially due to the undulation of the same soft decomposing schists which I am disposed to refer to the lowest members of the Upper Silurian rocks.

Advancing from New Galloway to the south, and as soon as we were free from the local influence of the granite of Cairn's Muir, we found numberless low ledges of greywacke schist trending chiefly from E.N.E. to W.S.W., in some of which the beds dipped south, in others north; the latter dip prevailing. This also obtains near Castle Douglas; and that the same undulations continue to Kircudbright is plainly seen in the bed of the transverse-flowing river Dee, which often exposes strata dipping both N. and S. In this manner we reached one of the southernmost headlands of the Scottish shore without being able to affirm that we were in strata of younger or older age than those we left at New Galloway on the north.

In Balmae Head itself, which Mr. Nicol and myself examined*, there are the same repetitions with many fractures. Fortunately so many fossils have been found in this place by Mr. Fleming of Kircudbright and others, that but little doubt can remain concerning the age of these rocks. The examination indeed of these Kircudbright fossils by Mr. Salter indicates that those beds could not be older than the Wenlock shale†. Prof. M'Coy has identified two from the same locality with Trenton Limestone species of N. America, but with a mark of doubt, and one, *Leptæna alternata*, without doubt‡.

They differ so essentially from the fossils of the Stinchar and Girvan banks, that one can hardly hesitate in considering these strata of Kircudbright as superior to those of the Ayrshire group. Nor is there any extraordinary thickness of strata to impede our arriving at this conclusion; seeing that, by undulation and repetition through fracture, all the sedimentary deposits of Wigton, Galloway, and Kir-

* The Earl of Selkirk, F.G.S., proprietor of Balmae Head and the adjacent country, informed me some years ago of the discovery of certain *Orthoceratites*, among which I then recognised the *O. annulatum* and other Wenlock shale types, and from that moment I had little doubt that the rocks were Upper Silurian. His lordship has recently sent me a few other fossils, collected by Mr. Fleming, which confirm the views of Mr. Salter.

† See List of Fossils, Quart. Journ. Geol. Soc. vol. iv. p. 206, and vol. vii. pp. 54, 55.

‡ Report Brit. Assoc. for 1850, p. 107.

cudbright belong to one and the same group, which is, on the whole, a younger formation than the Ayrshire rocks, and must, I conceive, be classed as Upper Silurian.

C. Dumfriesshire; Sections across the Central Silurian Region.

I will be as brief as possible in stating the principal facts which fell under the notice of my associate and self in the very general survey we made of Dumfriesshire. This country had previously been examined by Professor Sedgwick, who had collected many *Graptolites* from it, which have been recently described by Prof. M'Coy. Mr. Harkness had since our visit contributed many details* concerning what he has termed the Silurian rocks of that district, and has also described some *Graptolites*†. In examining these rocks, even up to the extreme northern frontier, near Sanquhar, there is an almost total absence of limestone and of any beds lithologically resembling the shelly sandstones of Ayrshire. The Caledonian railroad has, in fact, laid open an excellent section of all the strata from Lockerby on the south by Beattock near Moffat. Attaining its summit-level in the wild hills whence the sources of the Clyde, the Evan, the Annan, and the Tweed arise, this railroad descends to Abington before it emerges from the rocks of this age and enters into the coal-fields of Lanarkshire.

In examining the cuttings near Beattock, Prof. Nicol and myself detected one anticlinal north of that place, at which hard purple greywacke-sandstone passes under black carbonaceous and anthracitic schists, which in the bed of the rapid burn and deep glen of Garpool has afforded *Graptolites* to the persevering search of Mr. Harkness.

We also recognised the continuation of the great trap-dyke‡ of Coates Hill above Moffat, which, striking from N.W. to S.E., reappears at Craig Fell Hill on the right bank of the Annan, and is probably continuous to the igneous dykes on the Esk near Langholme, whose embranchments pass near Dumfries§.

Besides the flexure near Beattock, we observed, between that place and Aachen Castle, that beds, consisting of strong greywacke-flagstones or schists, often nearly vertical, dip at high angles to the S.S.E., whilst on the ascent of the railroad, as seen at the Greskin cuttings, and at other places, they plunge sharply to the N.N.W. at an angle of 75°. This latter dip is apparently continuous for some miles, the strata

* Quart. Journ. Geol. Soc. vol. vii. p. 46.

† Ibid. vol. vii. p. 58. & Pl. I.

‡ *Loc. cit.* p. 48.

§ No geologist has previously described this very remarkable dyke; still less has it been laid down in a map, though its length probably exceeds twenty-five miles. At Coates Hill it is an amygdaloidal basalt?, the fine prisms of which dip 75° N.W., their ends forming a peculiar mass in contact with the greywacke which they traverse. On the faces of the joints some serpentine appears. The kernels in the mass consist of white carbonate of lime, smaller portions of which are so *diffused* through the rock with chlorite and minute crystals of Labrador, that, like the prismatic trap of Welshpool, it forms an excellent and tractable building stone (see 'Silurian System,' p. 288).

consisting of flaggy, grey-coloured, and purple, hard greywacke with occasional courses of black schists.

At Rae Cleugh, near the turnpike-gate, any one looking at the form of the adjacent hills on the east would suppose that the sharp slope on the north was an escarpment, and that the strata would really be found to dip in the direction of the southern gentle slope. The actual section, however, of the railroad shows the very reverse, and exhibits the strata plunging N.N.W. at angles varying from 40° to 50°. Professor Sedgwick, who had previously examined this tract and collected many *Graptolites* from it, invited me indeed to try to mark the real axis of this central country by attending to the talus and scarp, or short and long slopes of these mountains. But however well I found this outline explained the folds of the strata in the Alps*, the test was worth nothing in this the highest tract of the South of Scotland.

In advancing to the summit-level of the railroad, wherever a dip is exposed it is still to the north; but, as considerable spaces are obscured and denuded, and no cuttings are visible, it is probable that there may be rapid flexures and fractures which cannot be detected in this rounded, grassy country. At the last cuttings near the summit-level, purple greywacke is followed by hard glossy schists with quartz veins, crystals of iron pyrites, &c., the whole dipping 75° to the N. or N.N.W. The descent of the railroad exposes only two cuttings, the valley being level and thickly covered with drift; but these also exhibit a northerly dip, and, from all that is visible, the same inclination is really continued to Abington! Professor Nicol, who examined the country near that place whilst I turned to the south to look at the strata near Lockerby, could detect there no trace of true limestone, but he found a light-grey, flinty slate, unlike any rock we had previously seen, and evidently, as he thought, metamorphic. Among those beds was a rude breccia of prismatic clay-slate mixed with limestone; the fragments of the latter having much the colour and aspect of the Wrae limestone in Peebleshire, which, according to the general strike, is in the direction to which this breccia would extend. It is therefore probable that the breccia is a thin continuation of the Wrae limestone, broken up and altered by the red felspar-porphyries and other igneous rocks which abound in this district. This is the tract of all others in the South of Scotland where the greywacke and clay-slate have been most modified, as around the base of the porphyry of Tinto Hill and in the Lead Hills. It has afforded the greatest amount of metalliferous veins, and in ancient times it was the site of gold-works amidst the drift derived from the altered rocks. We cannot look for order in such a tract. If, indeed, the calcareous breccia above alluded to be really the equivalent of the Wrae limestone, it seems rational to infer that the masses of schist, rising out from beneath it to form the highest hills of the region, are, as Professor Nicol suggested in 1849†, and revived in a discussion at

* See Quart. Journ. Geol. Soc. vol. v. p. 239 *et seq.*
† *Ibid.* vol. vi. p. 61.

the last Meeting of the British Association at Edinburgh, the oldest strata in the South of Scotland*. But the subject calls for closer researches before the question can be decided, and before we can class the Moffat and Dumfries group in the lowest division of the series.

In the immediate neighbourhood of Moffat, I made one detailed section of a few miles across the strike on another parallel (partly in company with Mr. Harkness), which also exhibited a very great persistence in a northerly dip; *i.e.* from the Craigie Burn and Hunter Heck over a hill marked by an Ordnance pole and across the Frenchland Burn to the hills on the north. In this space grey and purple flagstones with Annelids? or worm-like bodies, not unlike some of those (*Myrianites*) in the Lower Silurian rocks (formerly erroneously considered by myself to be Cambrian) near Lampeter in S. Wales, are found in the plantation quarry above Hunter Heck. These beds dip 72° to the N.N.W. under a higher summit, in part composed of reddish thin tilestones and of overlying masses of strong-bedded flag-like greywacke. These are followed by shale or schist, occupying a moory depression, and the hard greywacke, being renewed in the slopes, is succeeded by a band of jet-black, fissile, anthracitic schist, very pyritous in parts, and exhibiting *Graptolites*, as well as anthracite. The occurrence of anthracite in certain schists of the clay-slate of Dumfriesshire was cited by General Dirom† many years ago. Such natural appearances as are seen in this Frenchland Burn, viz. the black schist and anthracite beds, or 'ampelite' of the French, have naturally led persons, ignorant of geological succession, not only to hope for coal-seams, but even to open works‡.

I allude to this partial section east of Moffat, to show the impossibility, in this troubled region, of estimating the true order and succession of the strata by any appearances of the strike and dip on one line of traverse only. Thus, if the geologist proceed a little to the east of the sectional line, he would find the graptolite-schists apparently overlaid by a mass of strong-bedded, hard greywacke-grit, dipping 70° to the N.N.W.; but, in turning westwards a few hundred paces and in descending the same Frenchland Burn, another scene awaits him. There, beds of purple greywacke-flag, schist, glossy shillot, and pyritous shale are seen overlying an anthracitic course of about eight feet thick, the whole supported on strong-bedded greywacke-grit, which, rolling over, is followed in the descent of the stream by a similar succession of anthracite, schist, greywacke, &c., dipping S.W., instead of to the N.W. In truth, this turn of the Frenchland Burn is near the spot where igneous rocks, intruding into the strata, have greatly modified them, and have given rise to those accumulations of fractured, contorted, and aluminiferous or pyritous schists in which the mineral waters of Moffat take their rise. I could not

* Professor Sedgwick now entertains the same view, as appears in the printed abstract of his verbal communication at Edinburgh, which has appeared since this memoir was sent to press. See Rep. Brit. Assoc. for the Advancement of Science, 1850, Trans. of Sections, p. 104.

† General Dirom's observations are appended to an old map of Dumfriesshire, now difficult to be had, although I saw it in 1827.

‡ Quart. Journ. Geol. Soc. vol. vii. p. 50.

inspect the contortions in this Frenchland Burn and not be led to believe that at the period when this region underwent violent commotions, the curvatures and fractures most easily and naturally occurred in the graptolitic schists, which are much the softest in the series of these intractable and hard rocks. From their same soft quality, these schists have also been the more easily denuded, and hence, where no great and decided transverse rents afford the streams a course across the strata, their feeders or rivulets have frequently found their way along longitudinal depressions of schist, parallel to the strike of the strata.

The little which fell under my own observation to the south of Moffat is scarcely worthy of notice, now that the details worked out by Mr. Harkness are known; but I may note that, even in travelling from Beattock to Lockerby, it struck me that the chief axis of that tract, so much covered with drift and only exposing imperfect sections here and there, would be found to pass by a spot near Nethercleugh into the chain on the E.N.E., and to range by Dumfries on the W.S.W. Unquestionably the strata at Lockerby dip to the S.S.E., and as all the rocks near Torthorwald, together with those of the country south of that line, have the same inclination as laid down upon a map sent to the Geological Society by Mr. Harkness, it is natural to infer, that a powerful anticlinal passes somewhere near Dumfries. I suggested, indeed, to Mr. Harkness that such would prove to be the case, and his researches confirmed my anticipation, and led him to mark what may be called the anticlinal of Dryfe Water, the lower part of which river, before it empties itself into the Annan near Torwood, flows in accordance with the strike of the ancient rocks. I apprehend that there are many more such anticlinals in Dumfriesshire, if we could detect them. Whether the Criffel granite be, as Mr. Harkness suggests, the cause of this flexure, I have not satisfied myself; but, if so, it does not throw up any strata in which Silurian fossils occur. It must indeed be admitted that the purple and reddish hard greywacke of the tract near Dumfries has as antique an appearance as any of the rocks of this region. It more resembles the unfossiliferous rocks of St. David's and other places in Wales to which the Government surveyors have restricted the term "Cambrian," than any rocks I saw in this region of Scotland.

On the whole, there being scarcely any other fossils than *Graptolites* and certain obscure *Orthoceratites* with *Annelida* in the schists of Dumfriesshire, it is difficult to infer from such organic remains alone what is the age of the chief masses of strata in which such forms only are repeated. Judging by analogy, and referring to the portion of the Silurian rocks which in other regions has been found to contain the greatest number of *Graptolites*, Mr. Harkness has arrived at the conclusion that much of this region—under a very different type—may represent an upper portion of the Lower Silurian rocks. In my opinion he places these strata too high in the series; and the inference from all that we now know is, that they probably represent that great mass of Welsh schist which underlies the Llandeilo or Bala limestone, but is still superior to the lowest zone of Silurian life.

In reference to details, however, Mr. Harkness maintains that the three bands of anthracitic and alum shale with courses of *Graptolites*—in many parts a complete alum shale, owing to the quantity of decomposed pyrites it contains—are repetitions of the same band. It might, however, be possible, I think, to explain their repetition by great curvatures, the upper parts of which had been denuded, as well as by the occurrence of a series of parallel faults of great magnitude to which that author refers them*. His own sections show, indeed, a great parallelism between the strata on either side of these supposed faults.

Difficult as it may be in such a covered and broken region, to unravel the physical contortions to which it has been subjected, the task will doubtless be accomplished at some future day; and when this is done, I have no doubt that, gigantically thick as they may appear on a superficial survey, the older rocks of Dumfriesshire, like those of parts of the South of Scotland where we have been able to explore closely, will be reduced to reasonable dimensions. In the mean time, if the point be substantiated, we shall be much indebted to Mr. Harkness for labours, which lead us to believe that, whatever be their precise place in the Silurian series, the graptolite-schists of Dumfries are simply repetitions of one band—an important step in limiting the thickness of the strata†.

* Quart. Journ. Geol. Soc. vol. vii. pp. 51, 52.

† Although this is not the place to offer many observations on other rock-formations of this tract, I may state, in passing, that I am not yet satisfied that the Red Sandstone of Dumfries and Corn Cockle Muir is of the age of the Trias as suggested by Mr. Harkness (Quart. Journ. Geol. Soc. vol. vi. p. 389 *et seq.*). In the upper recesses of the valleys, and notably east of Moffat, this formation is a coarse shingly and quasi-angular conglomerate, made up of the debris of the Silurian greywacke on which it rests, and is there associated with deep-red sandstone. In its range southwards, I have not seen this same red sandstone also overlapping *un*conformably the edges of the carboniferous deposits. If those red rocks were really of the age of the "Bunter sandstein," they would surely (seeing their wide spread in Dumfriesshire) be somewhere seen in overlying and contrasted positions to the carboniferous rocks which were formed at a period so long anterior to them. My scepticism on this point acquires some strength from the recollection I have of red sandstones in Arran, which Professor Sedgwick and myself (even when we were introducing reforms into Scottish geology) classed as New Red, and which we now regard as Carboniferous. The truth is, so many of the Scottish sandstones from the Old Red upwards are of a red colour, that much discrimination will be required in separating those which are of Devonian from some which are of carboniferous, and from others which may probably be of Permian age. If I were to judge from the aspect of the rocks, their flag-like and hard character, and the great dislocations they have undergone (almost as great as those of the carboniferous limestone), I should prefer classing the Red Sandstone of Dumfries with the Permian. At present, as far as I know, geologists, guided exclusively by the footmarks, consider the impressions left by Reptiles at Corn Cockle Muir to belong to species whose footprints are found in the, so called, New Red of England. (See the forthcoming Ichnology of Annandale, by Sir W. Jardine, Bart.) But this is as yet doubtful evidence; for, with the exception of the Keuper sandstone, we really at present scarcely know what amount of rock beneath it ought to be classed with the Trias or New Red, or how high the Permian system, or summit of the palæozoic rocks (in which Reptiles also occur), should ascend in the English scale. A reference to section fig. 1, accompanying Mr. Harkness's paper (Quart. Journ. Geol. Soc. vol. vii. p. 52), will indicate the difficulty of sharply

Conclusion.

Although I know that much hard labour in the field is yet required before any one can lay down accurately the physical relations of the different rocks constituting the Silurian system of the South of Scotland, or can attempt to delineate in that region the changes in the sedimentary matter in the range of strata of the same age from the E.N.E. to W.S.W., enough has now been presented to the public by my precursors, with what has been now communicated*, to enable us to arrive at some positive conclusions.

Even if no geologist had carried thither his hammer and compass, the geographical observer and the artist would perceive throughout all the hilly tracts of the southern counties of Scotland, extending from the German Ocean to the Irish Sea, a sameness of outline in the soft and undulating contours of the ground. This outline, we may now fairly infer, is due to frequent bends of the stony framework. In examining many years ago, in company with Professor Sedgwick†, the sea-cliffs of St. Abb's Head, between Berwick and Siccar Point, I could not avoid being impressed with the rapid curvatures of the greywacke and the bold projections amidst it of masses of porphyry. Nor could I traverse the country from Dunglass to Dunse and not marvel at similar phænomena, whether the greywacke and schists of the Lammermuir Hills were of purple or grey colours, or their intrusive rocks were porphyries, greenstones, or amygdaloids. In a separate excursion, made last summer before he joined me, Prof. Nicol, on walking over these same hills near the coast, ascertained that, whilst the strike of the strata was persistent, there were no less than five anticlinals in the short space of three miles!

These facts, and the distinct proofs I have cited of numerous anticlinals, curvatures, and fractures in the coast-sections of Ayr and Wigtonshire on the west, and in Galloway and Kircudbright on the south, give us the key to explain the outline of the whole region. They teach us at the same time, that amidst these convoluted masses, intruded upon as they have been by numerous eruptive rocks, it must be impossible, without long-continued and close labour, to find the band which marks the oldest stratum or true geological axis. Thus,

separating, as he is disposed to do, the carboniferous limestone series from the Red Sandstone; for, after indicating a synclinal arrangement of the former in the bed of the Annan, and an anticlinal heave near Kelhead, he shows the formation to be so brought against the red rock, that, although separated by a fault, the latter dips to the south at precisely the same angle as its older neighbour. I do not believe that the British Isles afford a similar example of true *new red* sandstone being so related to rocks of the age of the carboniferous limestone.

* Mr. Cunningham has written memoirs communicated to the Highland Society, &c., which throw light on the dislocations and change of direction in the strata around the granitic and porphyritic tracts of Galloway and Kircudbright. We are also indebted to Mr. D. Sharpe for having put together all the later discoveries and observations of the geologists, who have explored Scotland, on a map, which has been very useful at the Geological Society in all recent discussions upon Scottish geology.

† Sir John Hall and Mr. Sheriff Alison were our associates. I much regret having lost my note-book in which the distinguished historian sketched many of the features of the bluff cliffs from the sea beneath them.

we have not yet sufficient grounds for inferring that the highest lands of this tract, from whence the Tweed, the Clyde, and the Annan descend, and which form the real geographical axis or watershed, are also the oldest strata. All inferences drawn from physical appearances, except the indisputable fact of great undulations and breaks, must indeed be deceptive, when we find that none of the South Scottish anticlinals are persistent for great distances. In one tract, as in the West of Ayrshire, the strata of a given structure dip more to the S.S.E. than to the N.N.W., and near Moffat nearly all the beds dip to the N.N.W. As yet, therefore, there is no possibility of absolutely determining by order of infraposition which is the lowest or oldest mass of stratified rock in the whole of the South of Scotland.

If we take the mineral character of the rocks, there are copious conglomerates peculiar to the Ayrshire tract, aluminous and anthracite shales in the central or Moffat country, and fine greywacke and clay-slate in the eastern region. Then, if we turn to the igneous rocks, we find serpentines and diallagic traps on the west at Girvan, granites cutting through as a transverse band from Criffel to Loch Doon, trap-dykes clearly posterior in Dumfries, bedded porphyry in Peebleshire, and massive amorphous porphyry and syenite in Berwickshire. With such diversity of original conditions and many subsequent modifications, very complex results must be expected. Amid these difficulties, we do know, however, that strata of vast thickness, including schists with limestone, and sandstone and grit with conglomerates, are charged with Lower Silurian fossils, and, as a whole, and after many undulations, are overlapped by other schists and slaty rocks in Kircudbright, in which Upper Silurian types of life prevail. When we come to examine this point more closely, and to be guided as we must be in so tortuous and convulsed a region by our only very sure guides, the organic remains, we find that, just as the convolutions prevent us from recognising either the distinct top or bottom of the whole Silurian series, so also the animal remains pertain, as they ought, chiefly to what must be called the central and lower portion of the Silurian system, if classification be regarded on the same broad scale in which it has been applied to the British Isles, Scandinavia, Russia, Bohemia, and America.

When I penned the first chapters on the Geology of Russia which treated of Silurian rocks in general, and also in previous communications to the Geological Society, I endeavoured to show (1844), that whilst the absolute zoological base of the Silurian system was wanting in Russia, and had not then been defined in the British Isles, it had, when followed northwards into Scandinavia, a true and indisputable existence. There, grits and arkose, made up of the oldest crystalline rocks of that region, are surmounted by schists and limestones, in which the presence of the genera *Olenus, Agnostus,* and *Paradoxides,* with other palæozoic fossils, marked, as I contended, *the earliest zone of recognizable life*. The admirable researches of our Government geologists have since developed precisely the same facts in North Wales, where the Harlech grits, overlying the unfossiliferous Cambrian slates, are surmounted by a zone containing the *Olenus* and *Paradoxides* with *Lingulæ*. The first-mentioned genus had, indeed, been previously described by Professor Phillips as occurring in black schists on the south-west flank of the Malvern Hills, which I formerly placed as Lower Silurian rocks. In Bohemia, which, of all countries in the world yet examined, exhibits, under the masterly delineation of M. Barrande, by far the most complete development of Silurian life, from its commencement to its close, the same band with *Olenus* and other fossils reposes, as in North Wales, on a vast thickness of azoic rocks, and is surmounted by the equivalents of the Llandeilo and Caradoc as well as by Upper Silurian formations. Now, in the South of Scotland no fossils have been discovered which clearly point to a lower horizon than that of Llandeilo; whilst many of the shells (in Ayrshire at least) would seem rather to belong to what I should call the superior division of the lower group. In using the term 'Caradoc sandstone' I must not be misunderstood. I know that the valuable researches of Professor Ramsay in the Silurian region and the adjacent parts of Wales have shown that much of what I formerly included in the Caradoc subdivision pertains rather to the Llandeilo group, both by physical association and by its unconformity to the Caradoc sandstone of Shropshire. It is therefore probable, that some of the Scottish shelly sandstones and conglomerates may represent such "Llandeilo Sandstones." Time and much close work can alone decide such points as these. But the essential consideration is, that even in Wales the overlap, elucidated by Professor Ramsay, has made no change in the upward development of animal life. All is Silurian. At least, many of the Upper Caradoc, and even of true Upper Silurian fossils have, it appears, existed in the period when the Llandeilo or Bala limestone was formed. In comparing Scottish and other distant rocks with those of Silurian age in England and Wales, we can, as I have all along contended, speak only of two great zoological divisions, the Upper and Lower Silurian forming *one natural system**. This inference is sustained not only by reference to well-known English and Welsh types, but also to Irish fossils from Galway and other places, where a number of Lower Silurian species are associated with many forms characteristic of the Upper Silurian rocks†.

Thus, whilst the Ayrshire limestones may very well be considered as on the same horizon as the Llandeilo and Bala limestones of South and North Wales, the shelly sandstones and conglomerates of Girvan are representatives of all the strata upwards which I regard as Lower Silurian, including the Caradoc sandstone; whilst the schists and flagstones with *Orthoceratites* and *Graptolites,* though I say it very doubtfully, may either represent the uppermost band of the Lower group, or the very bottom beds of the Upper Silurian rocks. In their undulations southwards these latter rocks become more developed, and, in unfolding a great thickness of graptolite-schists, expose the fossil bands of Kircudbright Bay, which are in all probability of the age of the known Wenlock shale.

* See Silurian System, p. 195, 308, *et passim*; Russia in Europe, vol. i. ch. 1 and 2.

† The steady strike of the fossiliferous Silurian rocks is seen in the Pentland Hills, in the greywacke of which Mr. Maclaren detected *Orthoceratites.* Although much obscured there by powerful masses of porphyry (all the intermediate country being occupied by coal-fields and trap), the Ayrshire zone of Silurians may be considered to reappear in the Pentland Hills on the true bearing to E.N.E.

The suggestion above alluded to, that the graptolitic and anthracitic schists of Moffat belong to a group inferior to all the other fossil-bearing strata of this region, may prove to be correct; and if so, these strata would represent the great schistose mass which lies beneath the Llandeilo or Bala limestone of Wales. But this inference requires confirmation. For, whilst a part of the researches of Professor Nicol and myself would lead me to entertain this view, there must be more exploration before I adopt it. If, for example, it be granted that the Wrae and Stinchar limestones and all the fossil-bearing strata of the northern zone be mineralized, metamorphosed, or attenuated on the north flank of the highest hills, and that they really there constitute an overlying mass, where in the numerous folds of the greywacke to the south of such geographical axis do we find any representatives of the fossiliferous Lower Silurian of the Ayrshire and northern bands? And yet, if that were the arrangement, we ought to detect some traces of such beds between the central axis and the Kircudbright strata which are the representatives of the Wenlock shale.

The establishment of *the lowest* strata of the region has yet to be determined by the discovery of the equivalents of the oldest Silurian zone of Wales, the Malvern Hills, Scandinavia, and Bohemia. By this I mean the band above spoken of, which is specially characterized by the minute crustacean, the *Olenus*, and certain forms of *Lingula* *.

The uppermost Silurian or Ludlow rocks are wanting in the South of Scotland, and, if they were ever deposited, are probably now depressed under the waters of the Irish Channel, forming a great undulating trough between the South of Scotland and the North of Wales. The evidences, however, which are left in the main land might lead us to believe, that beds of the true Ludlow age had never been deposited. Thus far is certain, that all those portions of the Old Red Sandstone which constitute the two lower divisions of that system in the North of Scotland have not yet been recognised in the southern border counties, where the only representative of the Old Red yet known is the conglomerate and sandstone with *Holoptychius*, which constitutes the upper member of the system in the Highlands †. In short, two-thirds of the Old Red or Devonian system and the uppermost member of the Silurian are absent along the English border. Hence we learn that at a very early period, the oldest deposits of the South of Scotland had been raised into lands, and were not depressed, even around their edges, until that subsequent period when the newer portion of the Old Red was formed, to be followed by the Carboniferous limestone, sandstone, and shale, and, with them, the associated coal of Scotland.

* Geologists can now study a fine succession of primordial life in the new and most instructive Museum of the Government Geological Survey, wherein Sir Henry De la Beche and his officers have also applied the term 'Silurian' to all the series from the *Lingula* and *Olenus* beds to the Ludlow rocks inclusive. The Government maps and sections are coloured on the same principle of classification and nomenclature.

† See Mr. Hugh Miller's 'Old Red Sandstone,' p. 156 *et passim*. Also the memoirs of Mr. W. Stevenson of Dunse, Proc. Geol. Soc. vol. iv. p. 29, and Quart. Journ. Geol. Soc. vol. vi. p. 418.

Whilst the Scottish Silurians often differ in aspect from the typical rocks of the same age in central England and Wales, many of them, however, bear a strong resemblance to their nearest equivalents of Cumberland and Westmoreland; and the strata in Kircudbright Bay may very well be compared with some of the Ireleth slates, described by Sedgwick*. I never shall forget my surprise when I first satisfied myself '*in situ*,' by inspecting their fossils, that the hard greywacke-flagstones of Kirkby Lonsdale were the equivalents of the Ludlow rocks, and that the calcareous slates of Ireleth were the true representatives of the soft Wenlock formation of Shropshire. Still less could I or any one else have supposed, that the incoherent plastic clay of the banks of the Neva and the green-grained rocks of St. Petersburgh (the "*craie chloritée*" of Brongniart) would prove to be as old as the slates of Snowdon!

Lastly, it appears to me certain, that all the above-mentioned varieties of greywacke, clay-slate, conglomerate, sandstone, and limestone of the southern Scottish counties constitute parts of one system only, and that, physically as well as zoologically, they are all knit together. Although full of local dislocations, folds, and numerous short axes of elevation, these deposits followed each other in seas tenanted by the same classes of animals, some in deep, others in shallow water,—some in a period of tranquillity, others during very powerful abrading action. In the prevalent absence of lime, and of mineral conditions favourable to the life or preservation of testaceous marine animals, the Silurian deposits of Scotland long remained in obscurity; but now, thanks to the opening-out of certain shelly oases within them, we are enabled to read off their history and to compare them with primæval types established by the survey of other regions.

END OF PART I.

In a second part of this Memoir, read before the Geological Society (February 26, 1851), I endeavoured to show from a section, made ten years ago, that the northern portion of the Sidlaw Hills in Forfarshire would be probably found to contain strata equivalent to the Uppermost Silurian or Ludlow rocks. That is one of the tracts of Scotland, in which, according to my notion, the lowest division of the Old Red Sandstone is most copiously developed, and there also rise out inferior beds of grey, micaceous sandstone and flagstone, some of them undistinguishable from the Ludlow rocks of England, and like them containing forms of the fossil crustacean *Pterygotus*, known to the workmen of the Scottish quarries under the name of the "Cherubim." In explaining this point, I referred to a report of a discovery (which seems to me to be very probable, but has not been confirmed) that *Graptolites* and other Silurian? fossils were found in the same tract, *i. e.* in a cutting of the Newtyle railroad.

I next described the symmetrical arrangement of a great anticlinal axis in the south-western Highlands, which I observed last summer,

* Proc. Geol. Soc. vol. iv. p. 580.

and to which I gave the name of Argyll's Bowling Green, from the well-known rugged mountains which occupy a portion of the central or axial mass. The section best exposed is that which is seen in passing from the Clyde, near Kilmun, to Strachur on Loch Fyne; the chief features of the central elevation and disturbance being admirably laid open on the shores of Loch Eck. This axial elevation explains, in my opinion, how various regularly stratified rocks (such stratification being obviously quite distinct from crystalline cleavage) have been rolled over and over in the Highlands, so as to form a series of broad and gnarled ridges and deep troughs, the major axes of both of which are parallel to the strike of the Silurian rocks of the South of Scotland. The Highland undulations have been accompanied by very deep fractures, both longitudinal and transversal, which are for the most part occupied by water. It follows, therefore, from this undulation of similar masses, that, after passing over several great mineral axes directed from W.S.W. to E.N.E., and often marked by copious extrusions of granite, porphyry, or greenstone, the geologist who reaches the valley of Ballyhulish, to the north of Glenco, finds himself upon clay-slate of the same age and character as that which he has left on the north bank of the Clyde!

After adducing many proofs, in addition to those put forth by Dr. MacCulloch, that the truly stratified rocks of the south-western Highlands must have been formed under water (whether the pebble-beds in the chlorite-schist of Ben Lomond, the bands of limestone in the mica-schist of Inverary, or the quartzose flagstones of the Forest of Glenorchy with their way-boards be considered), I have been led to infer, that some of these masses, particularly the upper clay-slate, might represent a portion of the Silurian system, and that others of inferior position were probably accumulated anteriorly to the creation of any animal whatever.

Being desirous, however, of not mingling theoretical views concerning the crystalline rocks of the Highlands with data which tend to establish the relative order of fossil-bearing strata in the South of Scotland, I defer the publication of my views on the former until more exhaustive surveys of the Highlands shall have been made.

Future researches may, as now suggested, lay open the uppermost member of the Silurian rocks (which is certainly wanting in the South of Scotland) in those northern tracts along the Sidlaw Hills, where the lower Old Red, or Devonian, is so fully developed; and, although we may have little chance of detecting fossils in the clay-slates or other rocks of the Highlands, we may yet be able by further labours to determine the existence in the southern Scottish counties of the very same zone of former life which has been recognised in Scandinavia, Bohemia, on the flanks of the Malvern Hills, and particularly in North Wales, as the oldest in which recognizable animal remains can be detected*.

* Murchison, Verneuil, and Keyserling, "Russia in Europe," &c., vol. i. ch. i.; Phillips, Mem. Geol. Survey of Great Britain, vol. ii. pt. 1. pp. 54, 55. Barrande on the Silurian Base of Bohemia, Rep. British Assoc. 1850, Trans. Sect. p. 99

List of some of the SILURIAN FOSSILS *of* AYRSHIRE.

By J. W. SALTER, Esq., F.G.S.

[The comparative abundance of the species is indicated by the number of asterisks.]

1. LOWEST BEDS,—LIMESTONE. (No. 3 of the Sections and Map.)

Aldeans Limestone.

Maclurea, new species. See description, p. 176. PL. VIII. fig. 7. *****
Murchisonia ——, sp.
Cytheropsis, n. sp. M'Coy's list in Rep. Brit. Assoc. 1850, Trans. Sect. p. 107.

Bogang, or Bugan, Knockdolian.

Asaphus (*Isotelus*), tail (probably the same as that found by Prof. Nicol in Peebleshire). PL. VIII. fig. 2.
Illænus latus, M'Coy (probably *I. Bowmanni* compressed).
Orthis calligramma, Dalm., the variety *virgata,* Sow. PL. VIII. fig. 4.
—— *confinis,* Salter. This resembles some of the Russian species. PL. VIII. fig. 5. *****
Maclurea magna, Hall, is quoted by M'Coy from this locality; we have small specimens of apparently the same species.

Craig Neil, near Colmonel.

Maclurea, the new species above mentioned. *****

Craig Head Limestone.

Cheirurus (*Amphion*) *gelasinosus,* Portlock, sp. PL. VIII. fig. 1.
Heliolites (*Palæopora*) *favosus,* M'Coy, sp.
Favosites alveolaris, Blainv. sp.
Petraia (*Turbinolopsis*) *elongata*?, Phill. sp.
Encrinite stems, very abundant.
Terebratula ——, sp. Probably a Canadian species. PL. VIII. fig. 3.
Orthis elegantula, Dalm.
—— *confinis,* Salter.
Leptæna or *Strophomena,* one or two species, imperfect.
Pleurorhynchus dipterus, Salter. PL. VIII. fig. 6.

The *Maclurea macromphala,* M'Coy, a species we have not seen, occurs also here in plenty.

2. CONGLOMERATE AND SHELLY SANDSTONE SERIES. (No. 2 of the Sections and Map.)

Conglomerates of Cuddystone Glen.

Encrinurus punctatus, Wahl. sp. Pl. IX. fig. 4. ***
Fenestella.
Petraia elongata, Phill. sp.? ****

Halysites catenulatus, Martini, sp. (*Catenipora escharoides,* Sil. Syst.).
Pentamerus oblongus, Sow.
Orthis calligramma, Dalm., var. *virgata*? Sow.
Leptæna sericea, Sow.
Murchisonia, an elongated species like *M. angustata,* Hall.

Mulloch Quarry, above Dalquharran (Shelly Sandstone).

Flattened groups of *egg-cases* of some *Gasteropod*? (Pl. IX. figs. 16, 17), very like, if not identical with, a common one in the Llandeilo limestones of South Wales. See description (p. 173) at end of the list. It is somewhat like those figured in Sir C. Lyell's 'Manual of Elementary Geology,' 3rd edit. p. 344, fig. 397, from the Old Red Sandstone.

Illænus ——, sp. Pl. IX. fig. 3. This fine species cannot be identified either with *I. Bowmanni* or *I. Davisii* of the Llandeilo flags; with the latter it has most resemblance. (Is this *I. Rosenbergii* of M'Coy's list?,—not of Eichwald.)
Phacops Stokesii, Milne-Edw. sp. (a Wenlock and Caradoc species). Pl. IX. fig. 2. **
Calymene Blumenbachii, Brong., from the Red Quarry (*C. subdiademata* of M'Coy's list).
Petraia æquisulcata, M'Coy. **
—— *subduplicata,* M'Coy. This much resembles *P. elongata* of Phillips. Pl. IX. fig. 7. *** And a variety with more equal lamellæ. Pl. IX. fig. 8.
Heliolites subrotundus, Fougt, sp. (*Porites pyriformis,* Sil. Syst.) See p. 144, note. Pl. IX. fig. 9.
Favosites alveolaris, Blainv., or *Gothlandicus,* Lamk. (Sil. Syst.).
Ptilodictya (*Stictopora*?, Hall) *acuta,* Hall, sp.; or this may be Prof. M'Coy's *P. costellata.* I have not been able carefully to compare the two.
Crinoidal stems, one smooth, one tubercled.
Orthis reversa, Salter. Pl. IX. fig. 13. ****
—— *elegantula,* Dalm.
Strophomena pecten, Dalm. sp.
—— *filosa,* Sow. sp.? **
Atrypa hemisphærica, Sow., a variety (*Hemithyris scotica,* M'Coy, MSS.), in which the ribs become more numerous towards the margin. Pl. IX. fig. 12. *****
Terebratula. Hemithyris angustifrons, M'Coy, MSS. Pl. IX. fig. 10. ******
Avicula ——, sp.
Turritella obsoleta, Sow., or possibly a *Murchisonia* allied to *M. angustata,* Hall. I cannot, however, see any band.
Murchisonia cancellatula, M'Coy, Rep. Brit. Assoc. 1850, Trans. Sect. p. 107; a beautiful reticulate species.
Maclurea, sp., a dextral shell.
Turbo ——, sp. allied to *T. trochleatus,* M'Coy. Pl. IX. fig. 15.
Trochus Moorei, M'Coy? Pl. IX. fig. 14.

Bellerophon dilatatus, Sow.
Orthoceras Barrandei, Salter. See descriptions, p. 177. Pl. IX. fig. 19.

Lower Thrave (Yellowish Sandstone).

Nearly all the fossils of Mulloch Quarry. The oval *Terebratula* (*H. angustifrons*, M'Coy) mentioned in the last locality, very abundant; *Atrypa hemisphærica*, *Phacops Stokesii*, &c.; with the addition of

Lichas laxatus, M'Coy. A Llandeilo-flag trilobite. Pl. IX. fig. 5.
Terebratula cuneata, Dalm. A Wenlock species. Pl. IX. fig. 11.
Orthis biforata, Schloth. sp. A common Silurian fossil, chiefly found in the Lower Division.

Saugh Hill (Sandstones).

Sandstone like that of Cong, Galway, Ireland, and with several of the same fossils.

Encrinurus punctatus, Wahl. sp., and its hypostome. Pl. IX. fig. 4.
Phacops Stokesii, M.-Edw. sp.
Tentaculites ornatus, Sow. A variety with coarser intermediate striæ than usual; and the rings too on the young part are more regular than in Dudley specimens; still it is probably only a variety. Pl. IX. fig. 6. ****
Petraia elongata, Phill. sp.? Chiefly in the conglomerates. *****
Halysites catenulatus, Martini, sp. Also in the conglomerates.
Favosites fibrosus, Goldf.
Heliolites inordinatus, Lonsd. sp.
Atrypa hemisphærica, Sow. The small ordinary variety. *****
Terebratula serrata, M'Coy. **
T. borealis, Schloth.
Pentamerus oblongus, Sow. Only in the conglomerates. *****
Leptæna sericea, Sow.
Strophomena, like *S. euglypha*, Dalm.
Pileopsis (*Nerita*, Sil. Syst.) *haliotis*, Sow. sp.

Drummuck (Shaly Beds).

Calymene Blumenbachii, Brong. Abundant; the true species, which in North Wales is found in Lower Silurian strata.
Illænus Bowmanni, Salter.
Cheirurus bimucronatus (Sil. Syst.). A large head and body-rings.
Bellerophon acutus, Sow. Pl. IX. fig. 18. ***
—— *dilatatus*, Sow.
—— *bilobatus*, Sow. **
—— sp. like *B. acutus*, but with wide umbilicus.

3. Orthoceratite and Graptolite Flagstones.
(No. 1 of the Sections and Map.)

Piedmont Glen.

Serpulites ——, sp.
Graptolithus tenuis, Portlock. Pl. X. fig. 1. **
Orthoceras politum, M'Coy. See p. 151, and note. Pl. X. figs. 5, 6. ***

Orthoceras vaginatum, Schloth.? Pl. X. fig. 7. Of this we have but one specimen.

——. A small species, with waved transverse lines.

Cyrtoceras ——, sp. Such are found both in Upper and Lower Silurian. Pl. X. fig. 8.

Ardwell.

Diplograpsus bullatus, Salter (comp. *Graptolithus pristis* of Hall). Pl. X. fig. 2. ***

Cyrtoceras. Same species as at Piedmont.

Orthoceras angulatum, Hisinger. Our specimen has coarser and more distant ribs than usual.

Orthoceras calamiteum, Münst. and Portlock. The distinct longitudinal ribs are not crossed by transverse ridges, but only by lines of growth, as in some Irish specimens of this variable species. This is *Orthoc. annellatum*, Hall, of M'Coy's list, cited above, and *O. bilineatum*, Hall (M'Coy *in lit.*).

Prof. M'Coy's list contains also *Leptæna sericea* and some other fossils. And both at Ardwell and Glenquapple he finds *Orthis simplex*, M'Coy, and at the latter locality *Leptæna sericea* :—both are Lower Silurian.

Knockgeirn.

Orbicula? crassa, Hall. A thin, finely striated shell, like *O. striata*, Sow. See description, p. 175. Pl. X. figs. 3, 4, and woodcut, p. 151. The same species occurs also in the Utica slate of New York.

Orthoceras politum, M'Coy. As above. Pl. X. figs. 5, 6.

Descriptions *of a few of the above* Fossils.

Graptolithus tenuis, Portlock, Geol. Rep. Londonderry, p. 319, pl. 19. f. 7. Pl. X. fig. 1.

G. tenuis, M'Coy, Synops. Classif. Brit. Palæoz. Rocks, Pt. 2. pl. 1 b. f. 4.

Congregated stems of this slender Graptolite occur in Piedmont Glen, which after careful examination I would refer to Portlock's *G. tenuis*; the original specimen of that species, however, is so obscure as to afford no definite characters. Our specimens, 4 or 5 inches long, have not suffered sufficient compression to flatten out all their parts; the empty canal has collapsed, and the very oblique cells show also a depression along their length from this cause; the narrow cell-mouths are very remote, each being opposite the base of the cell above it. There is an indentation, slight but still very constant, of the main canal opposite the base of each cell: Prof. M'Coy's figure does not show this, but he tells me that his specimens are frequently so, and believes it to be the consequence of contraction after death.

Locality. Piedmont Glen.

Diplograpsus* bullatus, Salter. Pl. X. fig. 2.

Prionotus pristis, Hising. Leth. Suec. Suppl. pl. 35. fig. 5?

Our specimens are not more than $1\frac{1}{4}$ inch long and a line wide. The rachis, which is convex, and puckered or bullate at short intervals, is broader than the cell-denticles; these latter, being the spaces between the cells, are broader and squarer in the young part, but diminish in breadth upwards as the size of the oblique cell-apertures increases. Our magnified figure shows the apertures too narrow, and the interspaces or denticles consequently too square for the adult portion, although this varies considerably in different specimens. On one compressed individual the thin solid axis is visible, but usually it cannot be detected.

Hall's figures of *G. pristis* (Pal. N. York, pl. 72. fig. 1) show a convex though not bullate rachis, and do not differ much in general character from ours; but until a better acquaintance with Hisinger's original species is obtained, it is thought better not to identify these Ayrshire specimens with it.

Locality. Ardwell and Piedmont Glen.

Nidulites favus, Salter. Pl. IX. figs. 16, 17.

The fossil to which the above name is applied is a frequent one in the Llandeilo flags of Pembrokeshire; at Haverfordwest particularly so, where it occurs associated with fossils very much of the same character as those from the strata here described. It occurs as oval or roundish plates, about 2 inches broad, spreading out from a centre (of attachment?) into a flattened irregularly wavy form; the entire surface of both upper and under sides covered with hexagonal cups, in our Scotch specimens a line wide, in the Welsh ones something less. These cups are about two-thirds their diameter deep, their edges smooth and even with the general surface, and their bases rounded and almost always with a central punctum or depressed point (which shows itself on the cast as a tubercle), and which is probably its point of attachment to the membrane or lamina forming the base for both series of cups. This membrane, whatever may have been its texture, is always absent in our specimens, a narrow space, as in fig. 17 *b*, being left between the upper and under series of cups, though some traces of its presence are to be seen in some sharp wrinkles which are seen radiating from the centre of the plate where one series is broken away. The lower surface of the cups themselves appear to have been a little wrinkled too towards their pedicle, as may be seen on the specimen fig. 17 *a*, where one series of cups has been separated from the opposite one before being fossilized, and where we have consequently only the impression of their lower surface. Such an impression has been figured (from this locality) by my friend Prof. M'Coy†, as a cast of his *Palæopora favosa*.

* "Barrande's synonym '*Diprion*' for this genus, is already applied to a genus of insects."—M'Coy *in litt.*

† Syn. Classif. Brit. Pal. Rocks, Pt. 2. pl. 1 c. fig. 3 *c, d*.

Were it not for the very large size of the cells, and the total absence of any diaphragm or covering to their wide mouths, it would have been natural to refer these double-sided cellular plates to the *Bryozoa*. I have to thank Prof. Milne-Edwards, however, for calling my attention to their analogy with the *Nidi* of Gasteropod Molluscs, the variety of arrangements among which are so striking*. If they are of this nature, *Murchisonia* seems to be the only genus likely to produce them, as that genus is plentiful in both districts where they occur. The name *Nidulites* might perhaps stand, whether they belong to the *Mollusca* or otherwise.

Locality. Mulloch Quarry, Dalquharran, in the shelly sandstones.

ORBICULA ? CRASSA, Hall. PL. X. figs. 3, 4 ; and Woodcut, fig. 7.

O. ? *crassa*, Hall, Palæont. N. York, pl. 79. fig. 8.

Round, generally wider than long, a little pointed anteriorly; umbo quite close to the anterior end, and much depressed; fine close-set striæ radiate from it, and increase in number towards the margin; they are crossed by still finer concentric lines (which show strongest between the radiating striæ), and by a few concentric rugæ. Shell thin. Breadth 8 lines.

As this appears to be exactly the same with some smaller specimens from the Utica slate of New York, I do not feel justified in giving a new name; but Hall describes his shell as marked by strong concentric wrinkles and fine radiating striæ, and his figure agrees with this in making the latter far less conspicuous than the former: in ours the reverse is the case, and the name *crassa* implies some thickness, while ours is a very thin shell. The woodcut, p. 151, shows a very well preserved specimen from Ardwell; those in the plate, from Penwhapple Glen, show a laminated structure in the shells, and some obscure traces of muscular impressions, which can, however, be hardly distinguished from the irregular wrinkles produced by pressure.

Locality. Ardwell and Penwhapple Glen, in Orthoceratite-flagstones.

PLEURORHYNCHUS DIPTERUS, Salter, var. RHOMBOIDEUS.
PL. VIII. fig. 6.

This is the third species of this genus as yet discovered in the Silurian rocks of Britain. In America they are frequent. Valves trapezoidal, oblique, and (excluding both the produced ends) longer than wide, convex, and with a broad keel running from the beak to the front margin in a direction slightly oblique forwards. The keel or central portion of each valve is a slightly elevated band, covered by very regular and close-set striæ of growth, crossed by a few obscure longitudinal ribs; it is most prominent (in this variety at least) on its forward edge, which ends on the ventral margin in a projecting point. The posterior wing is acutely triangular, extended backwards into a

* Dr. Lund (Annales des Sc. Nat. 1834, 2nd ser. vol. i. pl. 6. f. 27, 28) has figured some fossil egg-cases a good deal resembling the outer form; but no naturalist that I know of has seen a double series of equal-sized sacs arranged back to back, after the manner of a honeycomb.

point; and the lines of growth are here strong, coarse ridges, decussated by eighteen or nineteen radiating ribs, all of equal strength, except the few posterior ones, which are a little stronger. The anterior side (in the Irish specimens which I refer to this species) has a long straight spine (broken off in all our specimens), and in both it is divided unequally by a low ridge, which extends from the beak to the margin a little below the base of the spine, and defines a prominent lunette, below which the anterior slope is radiated by about seven ribs, crossed by nearly straight lines of growth. Length $6\frac{1}{2}$ lines. Breadth, exclusive of the anterior spine, 8 lines. Depth of valves united, 5 lines.

I believe this to be the same species with one which was obtained by the Geological Survey from the Chair of Kildare, Ireland, in a limestone equivalent to that of Llandeilo and Bala: we have three specimens, which all vary a little from each other, one having a much more decided angle on the anterior slope, the central keel flatter and more elevated, and not so projecting on its forward edge, and two or three of the longitudinal ribs very strong near the keel on either side, the rest faint. But I do not think this could form more than a variety, which might be named *interruptus*, since another specimen from the same locality much more nearly resembles our shell.

The species is easily distinguished from the *P. pristis* from Galway, as that species has the lunette sharply *depressed* and regularly ribbed, while the lower half of the anterior side is smooth. That shell too was probably a strongly carinate one.

Locality. Craig Head limestone.

MACLUREA ——, sp. PL. VIII. fig. 7.

M. magna, M'Coy, Rep. Brit. Assoc. 1850, 107.

Our specimen, 3 inches broad, is very incomplete, and is only figured to show the characteristic fossil of this band of limestone. But there are excellent specimens, from the same locality, at Cambridge, which agree well with ours, and show that the species had a considerably smaller umbilicus than the *M. magna*, Hall. The shell is high in proportion to its breadth, and has a character on the upper surface very available for specific distinction, viz. the much greater proportion of the outer whorl to the preceding one. In both Hall's and Emmons' figure of *M. magna*, the inner whorl is more than half the diameter of the outermost one—in ours it is scarcely above one-third.

In these proportions the shell before us a good deal resembles a fine species common in the Trenton limestone of Canada, and which I propose to name *M. Logani*, after the experienced geologist who has brought them over. In his fine collection from the Ottawa River, in company with numerous species of *Murchisonia, Pleurotomaria, Turbo, Turritella?, Scalites*, and other univalve shells, are numerous fine *Maclureæ* with many of the above characters; and associated with them, and in one case exactly fitting the mouth of the shell itself, occurs the most singular operculum ever discovered.

It is concentric and massive, while its muscular attachment to the shell is secured by a long and stout process from its inner surface, near the upper edge. This peculiar form of operculum will at once give generic rank to *Maclurea*.

Locality. Aldeans limestone.

ORTHOCERAS BARRANDEI, n. sp. PL. IX. fig. 19.

Short, tapering at an angle of 40°; acute at the extremity; the mouth broad and very oblique, surface covered by regular, close ridges of growth, which are not waved, but pass obliquely across parallel to the mouth; septa in the same direction, occupying half the length of the shell, and about one-sixth their diameter apart.

This shell is named in honour of the accomplished M. Barrande, who is engaged in figuring some hundreds of Cephalopods from strata of this age. He informs us he has several of this character, and some even more widely conical.

Locality. Mulloch Quarry.

ORTHOCERAS VAGINATUM, Schloth.? PL. X. fig. 7.

Orthoceratites vaginatus, Schlot., De Vern. Geol. Russia, vol. ii. pl. 24. fig. 6.

Our shell shows the transverse coarse striæ, but only indistinct traces of the annulations which occur on this curious Northern species; but as that circumstance alone would not be sufficient to distinguish it, we adopt the name. The oblique raised lines at each constriction of the siphon are due to the edges of the septa, which, according to De Verneuil's excellent figure of *O. duplex*, a closely allied species, pass down in the siphon through the space of several septa, so as to form a sheathed tube like that of *Nautilus sipho*.

Locality. Ardwell.

EXPLANATION OF PLATES VIII. IX. AND X.

PLATE VIII.

Fig. 1. *Cheirurus gelasinosus*, Portl. sp. Craig Head.
Fig. 2. *Asaphus* (*Isotelus*), sp. Bogang.
Figs. 3 *a*, 3 *b*. *Terebratula*, sp. Very like some from N. America. Craig Head.
Figs. 4 *a*, 4 *b*. *Orthis virgata*, Sow. Bogang, Knockdolian.
Fig. 5 *a*. *Orthis confinis*, Salter; ventral valve and its interior cast.
Fig. 5 *b*. The same; interior cast of the dorsal valve.
Fig. 5 *c*. The same; hinge-area.
Fig. 6 *a*. *Pleurorhynchus dipterus*, Salter, var. *rhomboideus*; side view, with the spine indicated, as in Irish specimens.
Fig. 6 *b*. The same; edge view.
Fig. 6 *c*. The same; middle part of the valve magnified.
Figs. 7 *a*, 7 *b*. *Maclurea*, sp. (*M. magna* of Prof. M'Coy's list). Aldeans.

PLATE IX.

Fig. 1 *a*. *Calymene Blumenbachii*, Brongn.; small specimen. Drummuck.
Fig. 1 *b*. The same; the emarginate hypostome attached beneath the head of a larger specimen. Drummuck.
Fig. 2 *a*. *Phacops Stokesii*, Milne-Edw. sp. Mulloch Quarry.

Fig. 2 *b*. The same; caudal shield. Mulloch Quarry.
Fig. 3. *Illænus*, sp. (*Ill. Bowmanni?*). Mulloch Quarry.
Fig. 4. *Encrinurus punctatus*, Brün. sp.
Fig. 5. *Lichas laxatus*, M'Coy.
Fig. 6 *a*. *Tentaculites ornatus*, Sow. var.; natural size.
Fig. 6 *b*. The same; magnified.
Fig. 7. *Petraia subduplicata*, M'Coy. Mulloch Quarry.
Fig. 8. Variety of the same, with more equal lamellæ. Mulloch Quarry.
Fig. 9. *Heliolites subrotundus*, Fougt, sp. (*Porites pyriformis*, Lonsd. Sil. Syst.); a cast of the tubes of the upper surface: they stand out in relief, and are slightly indented by the twelve small lamellæ.
Figs. 10 *a*, 10 *b*. *Hemithyris angustifrons*, M'Coy; interior cast of both valves.
Figs. 11 *a*, 11 *b*. *Terebratula cuneata*, Dalm.; two specimens. Lower Thrave.
Fig. 12 *a*. *Atrypa hemisphærica*, Sow. var. (*Hemithyris Scotica*, M'Coy); dorsal valve.
Fig. 12 *b*. The same; ventral valve.
Fig. 12 *c*. The same; interior cast of dorsal valve.
Fig. 13 *a*. *Orthis reversa*, Salter; interior cast of dorsal valve.
Fig. 13 *b*. The same; interior cast of ventral valve.
Fig. 13 *c*. The same; exterior surface of dorsal valve.
Fig. 14. *Trochus Moorei*, M'Coy? Mulloch Quarry.
Fig. 15. *Turbo*, sp.; probably new. Mulloch Quarry.
Fig. 16. *Nidulites favus*, Salter; cast of the lower side of one series of cups.
Fig. 17 *a*. The same; interior cast of one series of cups. Mulloch Quarry.
Fig. 17 *b*. The same; side view of complete plate, showing both series.
Fig. 18 *a*. *Bellerophon acutus*, Sow.; side view.
Fig. 18 *b*. The same; edge view.
Fig. 19. *Orthoceras Barrandei*, Salter. Mulloch Quarry. (N.B. The septa are too indistinctly marked in the figure.)

PLATE X.

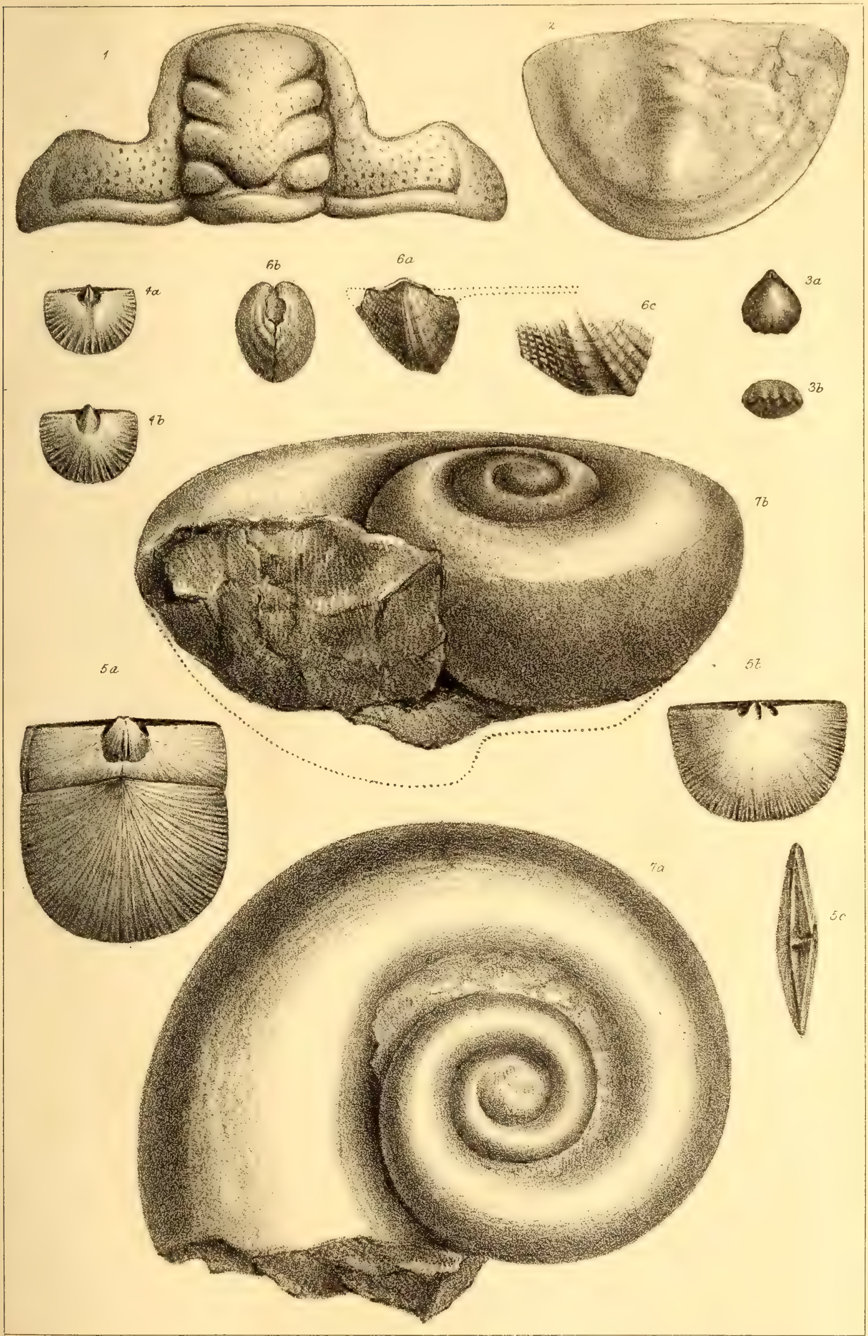
Fig. 1 *a*. *Graptolithus tenuis*, Portl.; natural size. Piedmont Glen.
Fig. 1 *b*. The same; magnified.
Fig. 2 *a*. *Diplograpsus bullatus*, Salter; natural size. Ardwell.
Fig. 2 *b*. The same; magnified, and viewed a little obliquely to show the thickness.
Figs. 3, 4. *Orbicula? crassa*, Hall. Penwhapple.
Fig. 5. *Orthoceras politum*, M'Coy; reduced one half.
Fig. 6 *a*. The same; showing the distance between the septa.
Fig. 6 *b*. The same; showing a septum and the siphuncle.
Fig. 7. *Orthoceras vaginatum*, Schloth.?
Fig. 8. *Cyrtoceras*, sp.

February 26, 1851.

The following communication was read:—

On the Silurian Rocks *of the* South *of* Scotland. Part II. By Sir Roderick Impey Murchison, G.C.St.S., F.R.S. G.S. L.S., Hon. Mem. R.S. Edinburgh, R.I. Ac., Mem. Imp. Ac. Sc. St. Petersburgh, Corr. Mem. Ac. France, Berlin, Turin, Copenhagen, &c. &c., and President of the Royal Geographical Society, London.

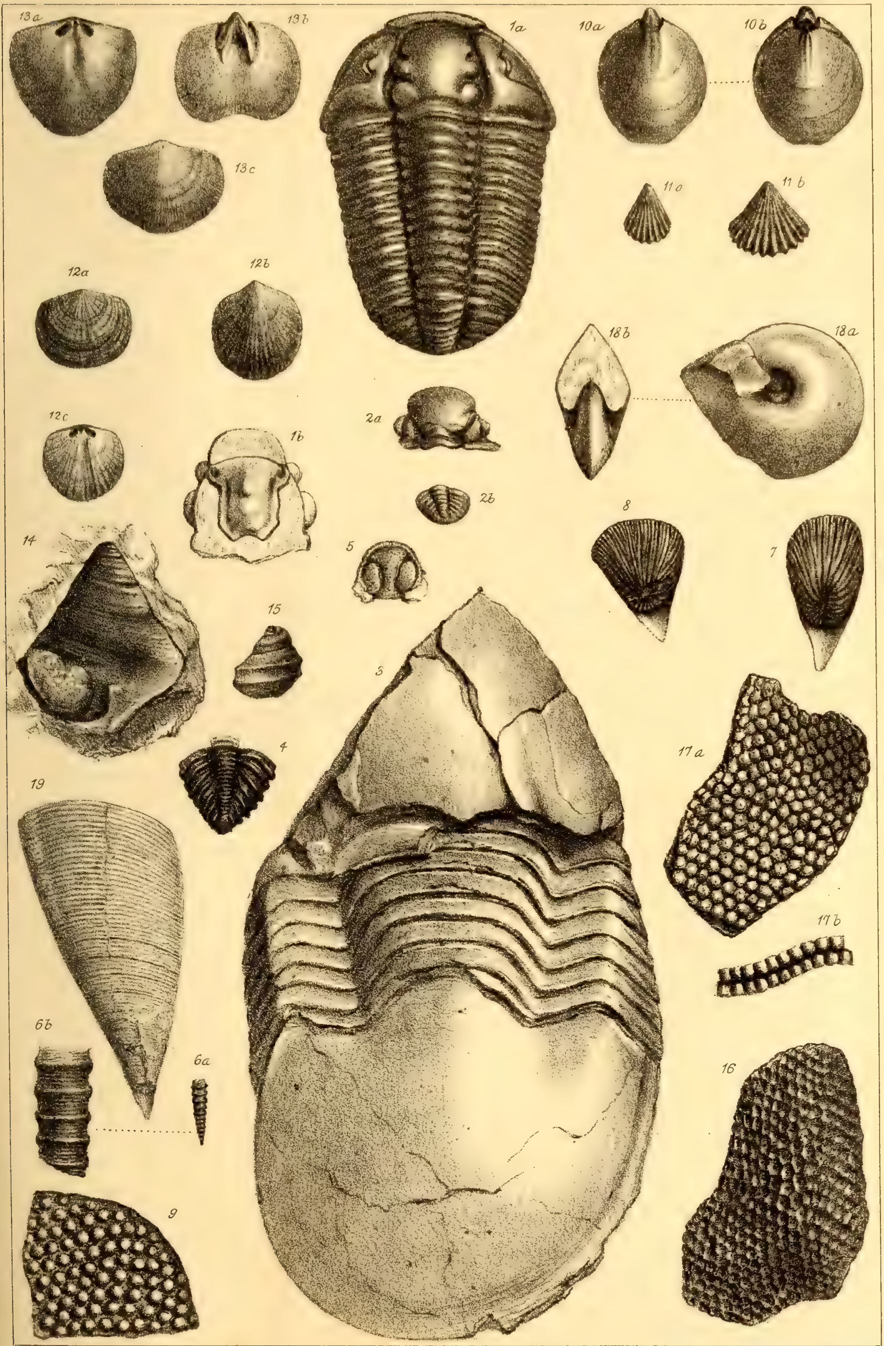
[Abstract printed with Part I. p. 168, above.]



W. H. Baily.

Ford & George, Imp, 54, Hatton Garden.

SILURIAN FOSSILS OF AYRSHIRE.



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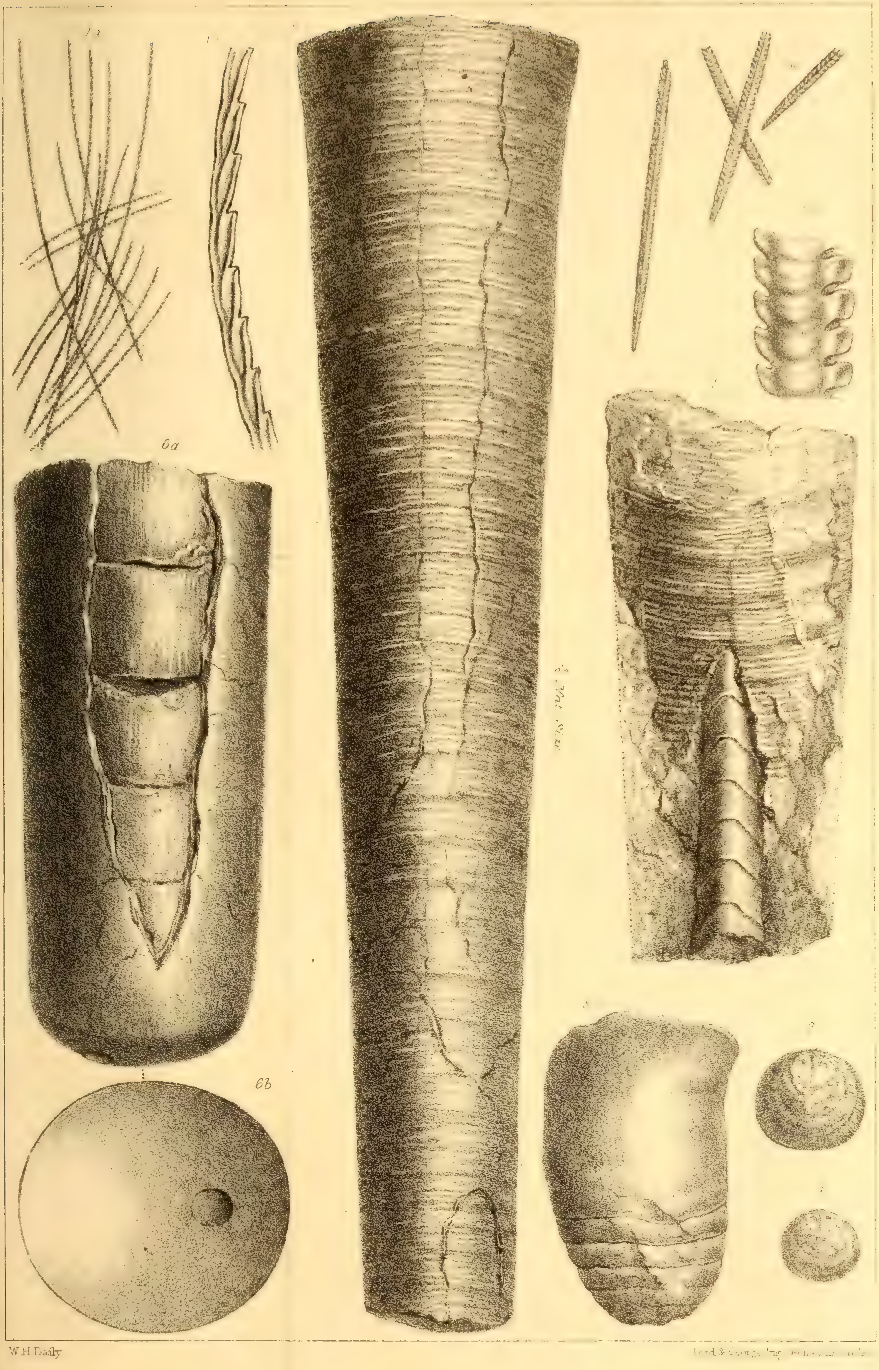

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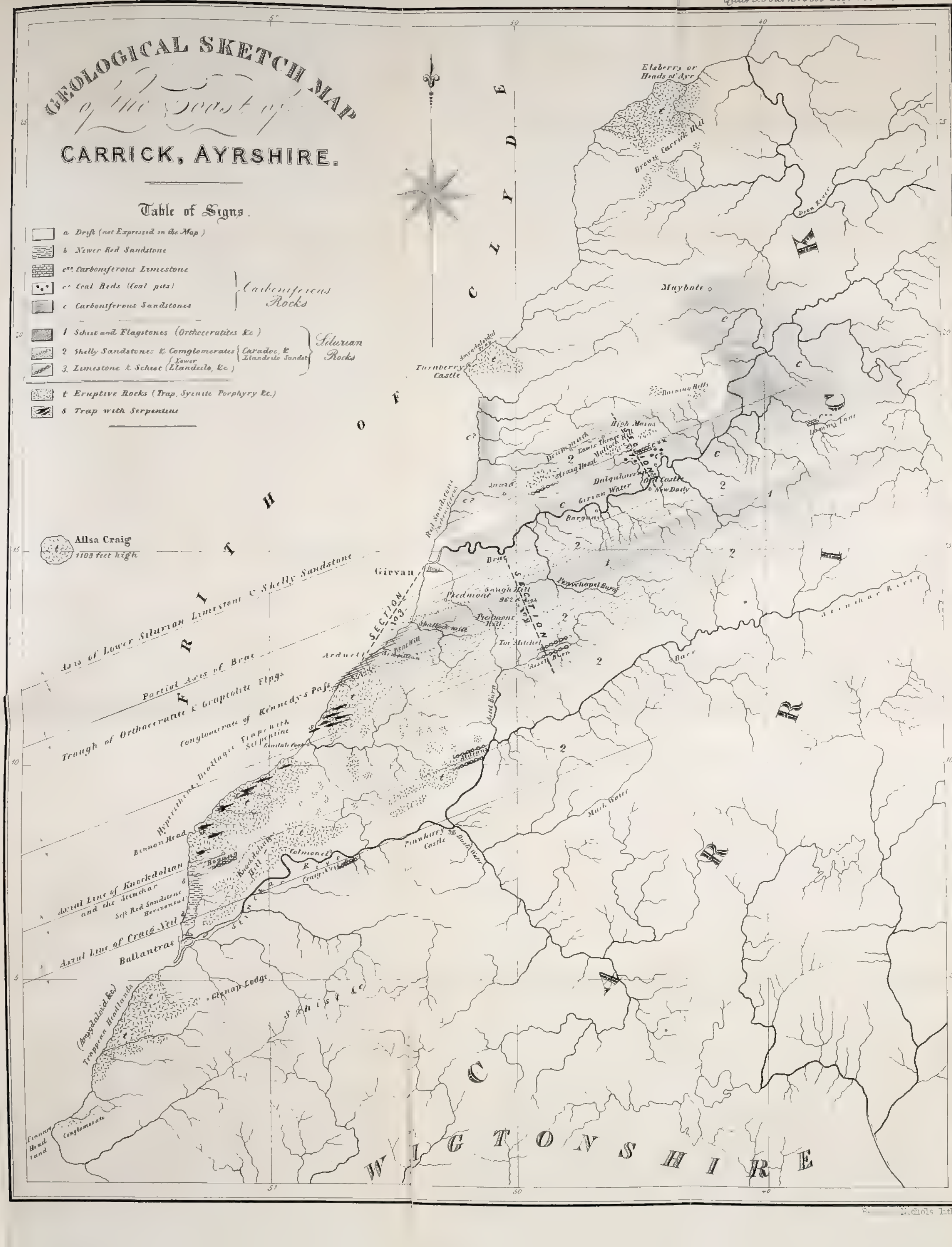
GEOLOGICAL SKETCH MAP
of the Coast of
CARRICK, AYRSHIRE.
Table of Signs.
a Drift (not Expressed in the Map)
b Newer Red Sandstone
c^{cs} Carboniferous Limestone
c^{o} Coal Beds (Coal pits)
c Carboniferous Sandstones
Carboniferous Rocks
1 Schist and Flagstones (Orthoceratites &c)
2 Shelly Sandstones & Conglomerates
3. Limestone & Schist (Llandeilo, &c)
Caradoc, & Lower Llandeilo Sandst.
Silurian Rocks
t Eruptive Rocks (Trap, Syenite Porphyry &c.)
s Trap with Serpentine
Ailsa Craig
1103 feet high
FIRTH OF CLYDE
CARRICK
WIGTONSHIRE
Elsberry or Heads of Ayr
Brown Carrick Hill
Doon River
Maybole
Turnberry Castle
High Mains
Dalquharran
Old Castle
New Dailly
Girvan Water
Bargany
Girvan
Brae
Saugh Hill
Pedmont
Tor Mitchel
Penwhapple Burn
Stinchar River
Barr
Assel Burn
Muck Water
Pinwherry Castle
Duisk Water
Colmonell
Craig Neil
Knockdolian Hill
Bennan Head
Ballantrae
Glenap Lodge
Schist &c
Finnart Head land
Conglomerate
Trappean Headlands (Amygdaloid &c)
Axis of Lower Silurian Limestone & Shelly Sandstone
Partial Axis of Brae
Trough of Orthoceratite & Graptolite Flags
Conglomerate of Kennedy's Pass
Hypersthenic Diallagic Trap with Serpentine
Axial Line of Knockdolian and the Stinchar
Soft Red Sandstone Horizontal
Axial Line of Craig Neil
Section No 3
Ardmillan
Red Sandstone

March 12, 1851.

Charles Johnston, Esq., and Capt. Richard Strachey, Bengal Engineers, were elected Fellows.

The following communications were read:—

1. *On some* Fossil Plants *from the* Jurassic Strata *of the* Yorkshire Coast. By C. J. F. Bunbury, Esq., F.R.S., For. Sec. G.S.

The sandstones and shales of the Oolitic series, in the neighbourhood of Scarborough and Whitby, have for many years been known to geologists as being singularly rich in fossil remains of plants, equally remarkable for their beautiful state of preservation as for the variety of forms assembled within a small space. It may be said, indeed, that but for the "plant-beds" at Gristhorpe, Cloughton, Kaiburn, and Whitby, we should know little of the ancient vegetation of the Jurassic period. These localities have supplied, in fact, the types of the Jurassic Flora, with which the comparatively few and scattered specimens of this vegetation, found in other places, have been compared. The first notice of this remarkable extinct Flora is, I believe, to be found in Messrs. Young and Bird's 'Geological Survey of the Yorkshire Coast,' in which a certain number of the most striking forms are very imperfectly represented. Many species are named and figured (but not described) in Professor Phillips's valuable work on the 'Geology of Yorkshire'; a considerable number are well illustrated in Lindley and Hutton's 'Fossil Flora,' and in the classical work of Adolphe Brongniart; and very recently the last-named author has given, in his 'Tableau des Genres de Végétaux Fossiles,' a list of 63 species of fossil plants from the Oolites of Scarborough and Whitby; in which list, however, he has omitted some previously published by Phillips and Lindley.

But these various works have not exhausted the subject. The rich collections at Scarborough, especially those of Dr. Murray and Mr. Bean, contain numerous unpublished forms of Jurassic plants, as well as valuable materials for clearing up the history of others hitherto obscure. In a recent visit to Scarborough, I had the advantage of repeatedly examining the collections above mentioned, which were opened to me with the utmost liberality; and I now lay before the Society some of the results of this examination. To the liberality and kindness of Dr. Murray I am especially indebted for the opportunity of drawing as well as describing the most remarkable of these plants, and I wish publicly to express my obligations to him.

1. Sphenopteris nephrocarpa, nov. sp. Pl. XII. fig. 1*a*, 1*b*.

The fructification of any kind of *Sphenopteris* is so great a rarity, that I consider the present specimen very interesting, although it is but a small fragment, too imperfect perhaps to allow the species to be positively determined. It is in the collection of Dr. Murray.

It belonged evidently to a very delicate and pretty Fern, very like some of the more finely-cut *Dicksoniæ* of the present day; and its fructification clearly shows that its real affinity was with that genus. The fragment is bipinnatifid: its rachis rather broadly bordered; the leaflets (pinnulæ) alternate, somewhat oblong in outline, regularly pinnatifid, with a strongly marked, wavy or slightly zigzag midrib; their segments separated a little more than half-way to the midrib, alternate, or in part nearly opposite, short, contracted below, dilated at their apices into the *indusia* containing the fructification, which are convex, with a rounded or rather reniform outline, their greatest diameter being transverse. No capsules are visible, the fructification being probably in a young state. In general, each segment is traversed by a single vein, and bears a single indusium, but a few of them are slightly two-lobed, bearing two indusia, and having their vein forked. The barren segments, of which only one is seen in this specimen, are fan-shaped, unequally and rather deeply toothed at the apex, with obtuse teeth; the veins radiating, without any midrib.

The *indusium*, which is all that we see of the fructification of this interesting little Fern, closely resembles in form and position the indusia of certain species of *Dicksonia*, of the *Culcita* group, especially *D. coniifolia* (Hooker)*. In these plants the indusium consists of two convex, reniform, equal or nearly equal valves, terminating the short lateral lobes or teeth of the leaflets. To show their similarity to our fossil *Sphenopteris*, I have drawn (Pl. XII. fig. 2) a leaflet of a recent *Dicksonia* (I believe, *D. coniifolia*), from New Granada†; whereby it will be seen that the indusium of the fossil so well agrees with that of the recent plant, in an immature state, as to leave little doubt that both belonged to the same genus. The species is, however, clearly different, the segments of the recent *Dicksonia*, when barren, being elongated and acute, the leaflets themselves longer and more taper-pointed, and the rachis on which they are set having a very narrow border; besides that the frond is of a more rigid aspect. It is only with this group or section of *Dicksonia* that our fossil can well be compared: in most of the other species, and particularly in those composing the subgenus *Patania*‡, the indusium is more cup-shaped, and opens towards the back of the leaf, not in the plane of its margin, as it does in *D. Culcita, coniifolia,* and *Martiana*; it is moreover, in the greater number, seated in the *sinuses* of the lobes or teeth, and not at their tips.

Of the numerous fossil Ferns included in the genus *Sphenopteris* of Brongniart, very few have been found with distinct traces of fructification; and I am not aware that any in this state, from the oolitic formations, have yet been published. Of those described and figured by Goeppert, which are all from the coal-formation, his *Hymenophyllites Humboldtii*§ perhaps comes nearest to the present plant, but is yet abundantly different. The form of the indusia in that

* Species Filicum, vol. i. p. 70, t. 24 A.
† No. 1009 of Linden's collection.
‡ See Hooker's Spec. Fil. vol. i. tab. 26–28.
§ Syst. Fil. Foss. p. 254. t. 31. f. 1, 2.

species, as represented by him, well agrees with that which is common in the recent *Hymenophylla,* while their reniform or transversely oblong shape, in ours, is more characteristic of *Dicksonia.* To that genus, I think it clear that our plant is allied, although in its technical characters there is nothing to exclude it from the *Hymenophyllites* of Goeppert. The texture of the frond is almost too vague and uncertain, in a fossil state, to afford good generic characters ; besides, there is no proof that the texture of this *Sphenopteris* was more membranous than that of *Dicksonia punctiloba** for instance ; and the distribution of the veins, one veinlet running into each ultimate lobe or segment, is the same in many *Dicksoniæ.* If the fructification were not so very rare, it might doubtless afford good characters for subdividing the genus *Sphenopteris,* which evidently includes types allied to several very distinct recent genera. But as it is, it appears to me that there is more practical convenience, for the present, in leaving this genus, however miscellaneous, united under the name and character originally assigned to it by Brongniart.

The *Balantites Martii,* Goepp., from the coal-formation of Silesia, is evidently allied to the genus *Dicksonia* as understood by Hooker, but to a different group of species from that to which I have compared our plant ; and in the form and division of its frond, it comes nearer to *Pecopteris* than to *Sphenopteris.*

Another and a very interesting fossil plant which I may here mention, as having in all probability belonged to the same tribe of Ferns, is the *Tympanophora racemosa* of the 'Fossil Flora,' figured in that work from such imperfect materials, that its affinities appeared altogether doubtful. The splendid specimens in Mr. Bean's collection show clearly that it was the fertile state of a Fern, having, like the *Dicksoneæ* and *Hymenophylleæ,* its fructification contained in terminal cup-shaped *indusia.* Mr. Bean's best specimen shows a very considerable portion of the frond, which is regularly tripinnate, and has thoroughly the aspect of a Fern : the main stalk rather thick, firm, and rigid ; the subdivisions slender and delicate, with no distinct leafy border or expansion ; the frond being, as in some recent Ferns, reduced to the mere skeleton or framework of veins. It has thus, as Brongniart remarks†, an evident analogy with the *Thyrsopteris elegans*‡, a very remarkable recent Fern from Juan Fernandez, in which the fertile part of the frond has no parenchyma, consisting solely of the ribs or skeleton of the tripinnatifid leaf, with the cup-like indusia terminating its ultimate divisions. It is very interesting to find these rare and singular types of structure common to two geological periods so widely separated.

The *Thyrsopteris* has fertile and barren branches on the same frond. In those specimens of the *Tympanophora* which I examined, there was no appearance of any barren leaflets, nor of one part of the frond being different from the rest ; but Mr. Bean, whose long study and close observation of the Scarborough fossils give great weight to his opinions, thinks that the *Pecopteris Murrayana,* Brongn., is the

* Hooker, Sp. Fil. vol. i. p. 79.

† Tableau des Genres, p. 26.

‡ Hooker, Gen. Fil. t. 44 A.

barren state of this plant. The aspect of the two is certainly very different, yet not more so than that of the barren and fertile states of various recent Ferns. I have not, myself, seen any specimens tending to prove the identity of the two. Brongniart, indeed, has represented in *P. Murrayana* an appearance strikingly similar to the indusium of an *Aspidium* or *Polystichum*; but, what is singular, he has totally omitted all mention of this in his description; and it is possible that the appearance may have been either purely accidental or produced by a parasitical Fungus.

The distinction of *Tympanophora*, as a genus, from *Sphenopteris*, or from Goeppert's *Trichomanites*, must rest mainly on the diversity of the barren and fertile leaflets, if this be really the case. Otherwise, I do not see how it is to be kept generically separate from the group just mentioned. The *Trichomanites Beinerti*, Goepp.*, so strongly resembles it, both in the extreme slenderness of the ultimate divisions of its frond, and in the form of its fruit-bearing cups, that one feels unwilling to place them in separate genera.

2. Baiera? gracilis, nov. sp. Pl. XII. fig. 3.

Schizopteris gracilis, Bean, MSS.

This plant is slightly noticed by M. Adolphe Brongniart in his 'Tableau des Genres' (p. 38), where, after speaking of the *Cyclopteris digitata* of the 'Fossil Flora,' which he refers (though with some doubt) to the genus *Baiera*, he mentions "une espèce des mêmes localités à lobes linéaires." This is all the published account that I can find of it; yet it does not appear to be very uncommon in the "Lower Sandstones" of the Scarborough series, for I saw several specimens of it in the collections of Dr. Murray, Mr. Bean, and Prof. Phillips, and procured one from a dealer at Scarborough. It is, without doubt, closely allied to the plant above mentioned, the *Cyclopteris Huttoni* of Sternberg and of Morris (*C. digitata*, Foss. Fl. t. 64): the general form of the frond, its dichotomous mode of division, and apparently its texture, are alike in both; but in the plant now before us the lobes are much longer and narrower than in the other, nearly linear, very slightly widening upwards, and acute at their tips. The stalk is long and narrow, striated and slightly channeled along its upper surface, expanding very gradually into the leaf, which is constantly and very deeply divided into two parts, each of these being again repeatedly bifid, with great regularity. The ultimate lobes are long, strictly linear, ending rather suddenly in a point. General outline of the leaf fan-shaped. Veins rather obscure, but they seem to be few, nearly simple, and parallel, very sparingly forked, not confluent; no trace of a midrib.

Mr. Bean gave this plant the MS. name of *Schizopteris gracilis*; but although it might be difficult to frame a generic definition which should separate it from the original *Schizopteris anomala*, the type of that genus, yet it appears to me clear that it has no near affinity with that truly anomalous plant. The mode of division of the frond,

* Syst. Fil. Foss. p. 265. t. 32. f. 1.

which is very regular in the one, remarkably irregular in the other, and the wide difference in the general aspect of the two plants, seem to indicate a difference of nature which forbids our placing them in the same genus. According to Brongniart's latest views*, the *Schizopteris anomala* still stands alone. Our plant seems to me clearly a congener of the *Cyclopteris* or *Baiera Huttoni*, although distinct enough as a species, not only by the form of the lobes, but by the mostly simple veins. The genus *Baiera*†, to which M. Brongniart is disposed to refer these two species, was originally founded on a plant from the lias of Bayreuth, which is characterized by a fan-shaped and lobed frond, with the primary veins dichotomous, the secondary veins forming a network of elongated angular meshes between the primary. This last character is considerably at variance with that of our two plants, which have veins simply dichotomous, without any trace (in general) of secondary veins. In one or two specimens of the *Cyclopteris Huttoni* (especially in one in Prof. Phillips's possession) I have indeed observed an appearance of minute transverse veinlets connecting the principal veins; but I feel doubtful whether this appearance may not be deceptive, since I could observe nothing like it in any of Dr. Murray's numerous specimens of the same plant, which I examined with care. Similar short transverse veinlets (like those of Monocotyledonous leaves) exist in the *Trichomanes floribundum*, but in no other recent Fern that I know. Although there is no other point of resemblance between that *Trichomanes* and the fossil plant in question, this example shows that such a peculiarity of venation would not suffice to exclude the *Cyclopteris* (*Baiera*) *Huttoni* from the order of Ferns.

I do not perceive any proof that these two fossil plants (*Baiera Huttoni* and *B. gracilis*) ought to be removed from the Ferns, although their form and aspect may be rather unusual in that family. The nearest approach to their characters that I know among recent Ferns is to be found in the barren fronds of *Acrostichum peltatum* and its allies (forming the genus *Rhipidopteris* of Schott): these resemble our fossils as well in the mode of division of the leaf, as in the distribution of the veins. M. Brongniart refers the two fossil species in question to *Marsileaceæ*, apparently because of their supposed affinity with the original *Baiera*. But they are at least as different in shape from the leaves of any recent *Marsileaceæ* as from recent Ferns, and their venation would accord as well with the one family as with the other; nor have they ever (as far as I can learn) been found in connection with anything resembling the peculiar fructification of the *Marsilea* tribe. M. Brongniart indeed conjectures that the so-called *Sphæreda paradoxa* may be the fructification of one or other of these plants; but this conjecture is unsupported by any evidence that I am aware of. My friend Professor Phillips is of opinion that the *Sphæreda* is connected with *Ctenis falcata*.

The *Cyclopteris* or *Baiera Huttoni* is easily distinguishable from Brongniart's *Cyclopteris digitata*, although, in the Scarborough collections, both are usually labeled with the same name. In Bron-

* Tableau des Genres, p. 34. † *Jeanpaulia*, Unger, Syn. p. 112.

gniart's plant, the frond is divided less than half-way down: its lobes contiguous, broad, not tapering downwards (or but very slightly so), abrupt or truncated at their extremities, and often emarginate; there is nothing of that tendency to a regular dichotomous division, which is conspicuous in the other; the general outline is a large segment of a circle,—more than a semicircle,—the outermost lobes pointing somewhat backwards. The texture of the leaf appears fine, close, and firm; the surface glossy; the veins slender, but sharp and very distinct. Lindley and Hutton's plant has its leaf (in all the specimens I have seen) cleft into two, quite down to the stalk: the divisions repeatedly lobed in a dichotomous manner; the lobes rather widely separated, more or less wedge-shaped, obtuse, but by no means truncated. The texture appears much coarser than in the first, with comparatively large and rather prominent cells, which give an appearance of roughness to the surface, apparently independent of the texture of the stone. The veins also are coarser, more nearly parallel, and less frequently forked. Whatever this plant may be, Brongniart's *Cyclopteris digitata* is undoubtedly a true Fern. This last seems to be confined to the *upper* plant-bed, or that of Gristhorpe; the *C. Huttoni* prevails more in the *lower* sandstones, but must have an extensive geological range, since it has been found by Dunker in the Wealden formation.

3. SAGENOPTERIS CUNEATA, Morris, Cat. Brit. Foss. p. 20.

Otopteris cuneata, L. & H. Foss. Fl. t. 155.

It appears very singular that this plant should have been referred by the authors of the 'Fossil Flora' to the genus *Otopteris*, since their own figure shows that it has none of the characters of that group. Professor Goeppert, who refers it to his *Adiantites*, appears not to have seen a specimen, and to have overlooked the reticulation of the veins, correctly represented in Lindley and Hutton's figure. I have examined, in Mr. Bean's collection, the identical specimen figured in the 'Fossil Flora,' and I am satisfied that Mr. Morris has judged rightly in referring this plant to the same genus with the *Sagenopteris* or *Glossopteris Phillipsii*. But I am inclined to go further, and to believe that the so-called *Otopteris cuneata* is merely an imperfect or abnormal state,—probably a seedling,—of the same *Sagenopteris Phillipsii*. Mr. Bean's specimen, just mentioned, has two obovate or subcuneate leaflets seated at the top of a broad flat stalk; there is no appearance of the stalk having been prolonged beyond them, or having borne other leaflets; the manner in which they are attached to the stalk by a narrow base, but not articulated with it, is exactly the same as in *Sagenopteris Phillipsii*; and the venation, which is very marked and peculiar, closely agrees, except that there is no distinct midrib. Another specimen in Mr. Bean's collection has, in the place of the *two* leaflets, a *single* terminal one, inversely heart-shaped, cleft rather deeply (but not half-way) into two lobes; the venation the same as in the other. This sort of variation in form appears to me quite analogous to what we often see in the primordial or seedling fronds of recent Ferns; and these are frequently more different from the mature state of the species to which they belong, than is one of our fossil plants from the other. With respect to the absence of midrib, which might be considered a distinctive character of the *S. cuneata*, I have seen specimens of the ordinary form of *S. Phillipsii* in which this rib was but slightly marked; and it is often faint or indistinct in the seedling leaves of Ferns, while strongly developed in the mature state of the same.

It remains to be inquired, whether the *Glossopteris Phillipsii* of the 'Fossil Flora' be really identical with the plant so called by Brongniart. I must observe in the first place, that the plate in the above-mentioned work does not accurately represent the venation,—at least as it appears in the numerous specimens I have examined. The veins go off at first from the midrib at an extremely acute angle, curving very gradually towards the margin, much as in *Neuropteris*; and the areolæ or meshes, formed by the anastomosing of their branches, are much longer and narrower, and at the same time less uniform in shape and size, than they are represented in the plate I allude to. M. Brongniart figures his *Glossopteris Phillipsii* with *free*, not reticulated veins; in his description he does not allude to this part of the character; but Prof. Goeppert, in describing Lindley and Hutton's plant, notices this glaring discrepancy between the figures given under the same name in the two works, and conjectures the plant intended by Brongniart to be essentially different from that of Lindley and Hutton. Brongniart himself, in his latest review of fossil botany*, comes to the same conclusion, and frames a new genus, *Phyllopteris*, for his original *Glossopteris Phillipsii*, stating that it agrees in its general form with the *Sagenopteris* of the same localities, but differs materially in its venation, which is not at all reticulated. He is of opinion also that the plant figured by Prof. Phillips in the 'Geology of Yorkshire,' is his *Phyllopteris*, and not the *Sagenopteris*. The accuracy of the great French botanist is above all suspicion; but I may observe, that his *Phyllopteris* must certainly be very rare; for in none of the collections that I examined at Scarborough and York, not even in Prof. Phillips's, could I find a single specimen answering to his description of this new genus. Mr. Phillips's original drawings, which he had the kindness to show me, and which are but imperfectly represented in the published work, show clearly that *his* plant was the *Sagenopteris*; and this is what we always find under the name of *Glossopteris Phillipsii* in the local collections. Its leaflets vary in breadth, and Mr. Phillips observes that the veins are more conspicuously reticulated in proportion as the leaflet is broader; a circumstance not without example in recent Ferns.

Goeppert formerly considered the narrower (and more common) form of this plant as the fertile frond, and the broader as the barren state of the same; but I believe no one has been able to detect the least trace of anything like fructification. Mr. Bean, on the other

* Tableau des Genres, p. 22.

hand, has given the name of *Glossopteris Dunnii* to the broader form, considering it as a distinct species.

It has often been remarked that the extinct plants and animals found in a fossil state are more dissimilar to those now existing, in proportion as the formation in which they occur is more ancient; that those in the oldest rocks are most unlike our present creation, and that in the secondary and tertiary periods they gradually approximate to it more and more. But however true this may be as a general rule, the Ferns, I think, form an exception to it. The Ferns of the Oolite can hardly be said, on the whole, to resemble the recent kinds more closely than do those of the Carboniferous period. The *Alethopteris lonchitica*, and its allies, found in the old Coal-formation, are so exceedingly similar to existing Ferns, that some care is required to distinguish them even specifically. The *Pecopterides* of the Coal-measures are not, generally speaking, less similar to recent Ferns than those of the Oolite. And our *Sagenopteris Phillipsii*, on the other hand, although there can be no doubt that it is a Fern, appears as different from all existing forms as any of those in the Coal-formation. Its venation indeed is not unlike that of some recent species,—of *Hemionitis*, for example; and the digitate form, though very rare, is not quite without recent analogy; but in no living Fern, at present known, is there the combination of the digitate frond with the reticulated venation.

4. Pecopteris cæspitosa, Phillips, Geol. Yorks. pl. 8. f. 10.

This remarkable plant, although there is a characteristic figure of it in Mr. Phillips's work, is entirely omitted by Brongniart (even in his latest list of fossil plants of the Oolite), by Goeppert, and by Unger. I mention it here, chiefly for the purpose of expressing a doubt respecting its true structure, which I think worthy of attention. Prof. Phillips gave it the name of *cæspitosa*, under the impression (as he informs me) that the specimen which he figured consisted of a cluster of pinnated fronds springing from a tufted rhizome; and this appearance is well expressed in his plate. But the specimen which I have examined in Dr. Murray's collection gives quite a different idea of the structure of the plant: it has all the appearance of a compound frond, with five or six pinnæ radiating in a *fingered* form from the top of a broad stalk, and spreading out all in one plane. Another specimen, which Mr. Phillips showed me in his own collection (and which he obtained after the publication of his work), presents a similar appearance. None of these, unfortunately, are sufficiently well-preserved to remove all doubt as to the real form of the plant; and it remains to be decided by the discovery of more perfect specimens, whether the frond of this *Pecopteris* was merely once pinnated, or digitate, with pinnated divisions. I think this a point worth the attention of those who may have an opportunity of making further researches in the Scarborough plant-beds. In either case this Fern appears to be a very distinct species from any other yet known in the same formation. If it had pinnated fronds springing from a tufted rootstock, it was probably a near ally of some species which have been found in the Wealden deposits of Northern Germany; and it may have been related either to the recent *Polypodia*, or to the *Blechna* and *Lomariæ*, to which latter perhaps it would have a nearer resemblance. On the other hand, a frond of the form which seems to be indicated by Dr. Murray's specimen would resemble the fossil genera *Laccopteris*, Goepp., and *Andriania**, F. Braun, to one or other of which it is very probable that our plant might be referred if its fructification were known. The described species (very few in number) of both these groups belong to the Lias of the district of Bayreuth.

I have only to add, that the veins, in all the specimens I have seen of *Pecopteris cæspitosa*, are ill preserved, but appear to resemble those of *P. Sulziana*, a species belonging to the Grès bigarré.

5. Acrostichites Williamsoni.

Pecopteris Williamsonis, Ad. Br. Hist. Vég. Foss. i. p. 324. t. 110. f. 1, 2; L. & H. Foss. Fl. t. 126.
—— *curtata*, Phillips, Geol. Yorks. t. 8. f. 12.
Acrostichites Williamsoni, Goeppert, Syst. Filic. Foss. p. 285.

I mention this common and well-known plant of the Yorkshire Oolite, merely for the sake of remarking, that I think it may be retained as a genus distinct from *Pecopteris*, under Goeppert's name of *Acrostichites*. It is true that the venation affords no character by which it can be known from the Neuropteroid section of *Pecopteris*; and the peculiar form of the leaflets would afford only a specific character; but the fructification is so remarkably different from that of all other *Pecopterides* which have yet been found in a fertile state, as to show that the plant naturally belongs to a different group; and at the same time it is of such frequent occurrence, that I see no practical inconvenience in taking it for the basis of a generic character. That the small round bodies which so frequently cover the back of the leaflets are really capsules (*sporangia*), and not scales or other mere appendages of the cuticle, is proved by a specimen in Dr. Murray's possession, where these capsules are so well preserved, so little crushed or distorted by pressure, that their form and structure, in which they quite resemble those of recent Ferns, can be distinctly seen with a lens. I observe also in some specimens, that the lower leaflets of the pinnæ are entirely covered with these bodies, the upper quite free from them, and that on some of the intermediate leaflets they cover a part only of the surface, but without forming definite spots or lines. All this is exactly analogous to what is seen in various recent Ferns of the *Acrostichum* group. It is true that in that tribe, the fertile fronds or leaflets are usually (but not always) different in shape from the barren; nor am I able to point out any recent species belonging to it, which has precisely the same arrangement of veins as this fossil. The name *Acrostichites*, therefore, must be taken as implying an affinity with the genus *Acrostichum* in its old and ex-

* See the descriptions of these genera in Brongniart's Tableau des Genres, p. 29.

tended sense, as characterized by the fructification and not by the veins. The generic character may be thus expressed :—

Frond bipinnate. *Leaflets* with a midrib; *lateral veins* oblique, dichotomous. *Fructification* closely covering the whole, or an indefinite part, of the under side of the unchanged leaflets; not forming definite *sori*.

I do not know of any other species referable to the genus; for the *Sagenopteris Phillipsii*, formerly placed in it by Goeppert, agrees with the present species in no one character, except such as are common to all Ferns.

6. PECOPTERIS EXILIS, Phillips, Geol. Yorks. t. 8. f. 16.
PL. XIII. fig. 5*a*, 5*b*.

P. obtusifolia, L. & H. Foss. Fl. t. 158.
Cyatheites obtusifolius, Goepp. Syst. Filic. Foss. p. 328.

I have satisfied myself by the examination of authentic specimens, that the *Pecopteris obtusifolia* of Lindley and Hutton is identical with Mr. Phillips's *P. exilis*; and the latter, as the earlier name, ought to be retained. *P. acutifolia* (Foss. Fl. t. 157), which differs in nothing but the acute tips of its leaflets, can hardly be considered as a distinct species. It is singular that both should be omitted in M. Brongniart's catalogue of the fossil plants of the Oolite. Prof. Goeppert placed them in his genus *Cyatheites*, remarking at the same time that it was very possible their real affinity might rather be with the *Aspidia*. In their general form they certainly have quite the look of that genus; but in one specimen that I have examined of *P. exilis*, the appearance of the fructification is such as seems to indicate an affinity with quite a different group of Ferns. The capsules in this specimen appear not to form *sori*, but to be arranged singly in a regular row on each side of the midrib: each capsule is of a large size in proportion to the leaflet, of a figure between ovate and spherical, and marked on the top with distinct and regular striæ radiating from a depressed central point. Their structure, in short, appears extremely similar to what is seen in the recent *Schizæaceæ*, especially in *Anemia* and *Mohria*; the only difference, as far as I can make out, is, that in all the recent Ferns of that tribe, the capsules are crowded together on a part of the frond which is more or less contracted and transformed; whereas in our fossil, they are more distantly placed on the *unchanged* leaflets. The only fossil Fern hitherto described, in which such a structure of the capsules has been observed, is the *Senftenbergia elegans*, so elaborately figured and described by Corda*: this is very like our *Pecopteris exilis* in the form of its leaflets, and the position and general appearance of its capsules; but it has the terminal ring of those capsules composed of several rows of radiating cells, whereas in our plant there appears to be only one row of such cells, as is the case in all the recent kinds. Corda's *Senftenbergia* is a fossil of the Coal-formation.

* Beiträge, p. 91. tab. 57. f. 1–6.

7. Asterophyllites? lateralis.

Equisetum laterale, L. & H. Foss. Fl. t. 186.

A very fine and remarkable specimen of this, in Mr. Bean's collection, shows, I think conclusively, that the plant could not have been an *Equisetum*; for at two or three of its articulations it bears whorls of distinct *leaves*,—flat, narrow, one-ribbed spreading leaves, exactly like those of an *Asterophyllites*. It is hardly necessary to say that no *Equisetum* has leaves, nor anything to represent them, except the ribbed and toothed sheaths which envelope the stem for a certain distance above each articulation. The stem of an *Equisetum* bears, indeed, whorls of slender, jointed, furrowed branches; but I am satisfied that the appendages observed on the stem of the fossil in question are not of this nature; nor are they prolongations of the teeth of a sheath, but distinct leaves. This being the case, the plant must, I think, be removed altogether from the genus *Equisetum* or *Equisetites*; but what its real affinities may be, I am at a loss to say. It might perhaps be placed for the present in the genus *Asterophyllites*, which is itself a purely provisional and artificial group, of very doubtful affinity, but probably, in part, connected with *Calamites*. Our plant indeed combines some of the characters of both genera, having the leaves of *Asterophyllites*, with the circular radiated disks (the scars, apparently, of disarticulated branches), which occur in several *Calamites*.

This seems to be a characteristic fossil of the *Lower* carbonaceous sandstone of the Scarborough group, which is supposed to be intermediate in age between the Great Oolite and Inferior Oolite of the south-western counties. It is perhaps hardly necessary to remark the error into which Dr. Unger has fallen, in enumerating this and most of the Scarborough plants among the fossils of the *Lias*.

8. Calamites Beanii, nobis.

Calamites giganteus, Bean, MSS.

At the time when I described the fossil plants from Richmond in Virginia*, I was not aware of the existence of true *Calamites* in the Oolite of Britain; nor do I, even now, find this fact noticed in any published work. The only *Calamites* of the Oolitic period which are mentioned either by Brongniart or Unger, are the *Calam. Lehmannianus* from Silesia, and *C. Hoerensis* from Scania; both of which are marked by M. Brongniart as doubtful species. But in Mr. Bean's collection I saw several specimens of a large and conspicuous Calamite, to all appearance a new species, from the lower division of the carbonaceous sandstones of the Yorkshire coast. As I have elsewhere observed, it is very difficult to find trustworthy specific distinctions in this genus; but the Scarborough Calamite is very different in appearance from that which is characteristic of the Richmond basin, as well as from the true *C. arenaceus*. It is charac-

* Quart. Journ. Geol. Soc. 1847, vol. iii. p. 281.

terized in particular by its remarkably tumid articulations, the stem being much thicker in those parts than in the intermediate spaces. With the two plants above-mentioned it agrees in the apparent want of tubercles at the articulations; but the ridges of its stem are much broader than in either, and it is quite destitute of the wrinkled or puckered appearance usually so striking in the Richmond Calamite. Whether it belongs to what M. Brongniart considers as the true genus *Calamites*, or to his *Calamodendron*, I am unable to say, as it preserves no trace either of the bark or of the internal structure, in which alone the distinctive characters are to be found.

The specific name of *giganteus*, assigned by Mr. Bean to this fossil (but not published), seems too near to that of *gigas*, long since given by Brongniart to a very different species; neither is it particularly appropriate to a plant which is surpassed in size by several others of the genus. I would therefore propose to substitute for it the name of *Calamites Beanii*.

I may here observe that, in the opinion of M. Adolphe Brongniart, the Calamite of Richmond in Virginia is quite different from the true *C. arenaceus* of the Keuper formation. There certainly is a considerable difference in the general aspect of the two plants, although I have been unable to find any clear distinctive characters. *C. arenaceus* is of a much more slender habit than the other, and never exhibits those irregular transverse wrinkles which are so common (though not constant) in the American kind. This latter, if really distinct, should bear the name of *C. Rogersii*, in commemoration of the eminent American geologist who first distinguished it from *C. Suckovii*. The true *C. arenaceus* may then be considered as peculiar to the Triassic system; and it seems to be almost the only fossil plant which is common to the upper and lower members of that system,—the Keuper and the Variegated Sandstone.

9. Cryptomerites? divaricatus, n. sp. Pl. XIII. fig. 4*a*, 4*b*.

For the opportunity of describing and figuring this plant I am indebted to Dr. Murray, in whose collection I observed two specimens. It is, I think, undoubtedly a Conifer, and very distinct from any fossil species hitherto known, although, from the absence of fructification, its precise affinities must remain somewhat doubtful. In the best-preserved specimen, the ramification is pretty regularly bipinnate, with alternate and rather distant branches: no tendency in any part to a dichotomous division. The main axis of the specimen (which is perhaps a principal branch) is stout, straight, and rigid: its surface irregularly striated, without any appearance of distinct areoles; the branches and branchlets spread widely and stiffly, having a rigid and wiry aspect, although the branchlets are very slender and somewhat zigzag. Leaves apparently two-ranked, mostly alternate, but placed at very irregular intervals, and often nearly opposite; they are compressed sideways, and taper regularly from their vertically dilated decurrent base to a sharp point; are of a rigid appearance, most commonly straight, sometimes decidedly incurved; have no prominent lateral rib or angle, but are rather faintly and irregularly striated, perhaps in consequence of the shrinking of their tissue. Those towards the base of each twig are often (but not constantly) rather shorter than the rest. The main axis bears leaves of the same form as the others, but very distantly placed, and very stiff and straight, looking almost like spines. I could perceive no trace of anything like fructification.

I saw another specimen, of what I believe to be the same thing, in Prof. Phillips's collection; but in this, the ramification is more crowded and irregular, the branches and twigs apparently less stiff, everywhere more wavy or zigzag, and in parts remarkably so.

The ramification and general form of this plant show, I think, that its place is in the Coniferous order, and not among the *Lycopodia.* By the form of its leaves it reminds one of the *Cryptomeria,* and of the *Araucaria excelsa* and *Cunninghamii*; but as the same form of leaves is found in both those genera of recent Conifers, which differ widely in other respects, it cannot suffice to determine positively the immediate affinities of our fossil. These indeed must remain uncertain until something be known of its fruit; but in the mean time I assign to it the provisional name of *Cryptomerites,* without meaning to affirm that it is truly a congener of the *Cryptomeria Japonica.*

10. Palissya? Williamsonis[-ni], Ad. Br. Tableau, p. 106.

Lycopodites Williamsonis, Ad. Br. Prodr. p. 83; L. & H. Foss. Fl. t. 93.
Lycopodites uncifolius, Phill. Geol. Yorks. i. p. 119. tab. 8. fig. 3.
Walchia Williamsonis, Morris, Cat. Brit. Foss. p. 25.

Although one of the most common fossil plants of the Gristhorpe beds, this is still in need of further examination, to determine with more precision its real affinities. Brongniart remarked some time ago, that it was rather a Coniferous plant than a *Lycopodium*; and in his 'Tableau des Genres' he accordingly enumerates it among the Conifers, but seems uncertain as to its genus; for at page 40 of that work he speaks of it as a *Walchia,* whereas at pp. 68 and 106 he notices it under the new genus *Palissya.* The *Coniferæ* and the *Lycopodia* are, in truth, in many cases so like one another in the outward appearance of their leaves and branches, and even of their fruit, that it is no wonder that in the fossil state it should be difficult to distinguish them. The difference of size, which is in general sufficiently striking in the recent forms of the two orders, will afford us no assistance among the fossils. Of course, where the internal structure, either of the stem or of the cones, can be ascertained, there is no room for doubt; but, unfortunately, in the fossil remains this is very rarely the case. The best outward mark of distinction that I know of, is the dichotomous ramification of the Lycopodiums, contrasted with the pinnate arrangement of the branches in the Conifers. Even this sometimes fails us; for although the regularly dichotomous mode of division never, I believe, occurs in the Conifers, it is by no means obvious in some Lycopodiums, where, on the contrary, the stem appears to be pretty regularly pinnated with alternate branches. M. Brongniart* formerly pointed out another distinction: that, in the *Coniferæ,* the leaves at the end of each annual shoot are much crowded together, while the base of the shoot is nearly bare of leaves, or has them much smaller than the rest; so as to produce an appearance of interruption or contraction in the branches, corresponding to the annual interruption and renewal of growth. But this very same appearance is observable in the *Lycopodium annotinum,* which indeed derives its name therefrom, and is often very conspicuous (though not constant) in *L. clavatum.*

I conclude, then, that neither the stem nor the leaves afford any outward characters whereby we may with certainty distinguish these two natural families, which, although they belong to different natural classes, have yet so remarkable an outward similarity, that the one may be fairly said to represent the other. Hence, although I have scarcely any doubt that the so-called *Lycopodites Williamsoni* is rightly placed in the Coniferous order, yet we can hardly be quite certain of it without knowing something of the internal structure of its fruit. The cones are not, indeed, of very rare occurrence, but are always, as far as I have seen, so much compressed and crushed, that the important points of their structure cannot be ascertained. I may observe, however, that the small and apparently immature cones which are seen attached to the ends of the branches, in several specimens of this plant, have much more resemblance to the young female cones of a Pine or Fir, than to anything in the Club-mosses. I have not seen them in a sufficiently perfect state to allow of an accurate comparison with the full-grown cones, but their scales do not appear to be drawn out into long points like those of the latter; whereas, in a *Lycopodium,* the youngest cones or spikes of fructification differ in nothing but size from the oldest. It is possible, indeed, that these bodies may be catkins of *male* flowers; in which case they would be decisive of the question; but I must own that they have more the look of the young *female* cones of a Pine, as they appear in the flowering season. Usually they are solitary; but a remarkable specimen, shown me by Prof. Phillips, has *four* of them closely clustered together at the end of a branch.

This plant has a striking resemblance, in its ramification and the characters of its foliage, to the *Voltziæ* of the New Red Sandstone; but that remarkable genus is characterized by the peculiar form and arrangement of the scales of its cone, which are dilated upwards from a narrow base or claw, divided into three or five lobes, and very loosely imbricated. The genus *Palissya,* to which Brongniart (though doubtfully) refers our plant, was founded by Endlicher on a fossil (the *Cunninghamites sphenolepis* of Braun) from the Lias of Bayreuth. I must acknowledge that, judging from Endlicher's description, the resemblance between this Bayreuth plant and ours is not very evident. *Walchia* differs in the closely and regularly pectinated or feather-like arrangement of its branches, resembling the Norfolk Island Pine. On

* Prodrome, p. 81.

the whole, until its fructification be better known, it is difficult to refer this spurious *Lycopodites* to its proper genus.

There is a great likeness between *Palissya? Williamsoni* and my *Lepidodendron? binerve**, from the coal-formation of Cape Breton: they are alike not only in the aspect of their foliage, but in the form and position of their cones. But the Cape Breton plant is dichotomously branched, whereas in that now under consideration the branches are irregularly alternate. I may remark that the leaves of *P. Williamsoni* are certainly not two-ranked, as they have sometimes been described, but spirally arranged round the branches, although not with great regularity.

I observed in Prof. Phillips's collection, and in the York Museum, some specimens of what I conceive to be detached scales of a cone. Mr. Phillips indeed has noticed them in his work as "winged seeds†," but they appear to me more like scales, belonging in all probability to the Coniferous order, although certainly not to the present species. They are wedge-shaped, flattish, and thin; gradually thinning out still more towards the edges, which are quite entire; and they appeared to me to be marked towards their base with the impression of either one or two seeds,—I could not quite ascertain which. They are not likely to have belonged to Cycads, for in all the cone-bearing forms of that order the scales are of a very different form and structure, having a distinct stalk, and a dilated disk-like top, expanding nearly at right angles to the stalk. Moreover, the seeds of a Cycadeous plant are inserted on each scale, immediately below or behind its dilated disk; whereas, in the scales I speak of, the supposed impressions of seeds are situated near the base, which agrees with their position in the Conifers.

The collections at Scarborough contain several undescribed Cycads, especially of the genus *Otozamites* (*Otopteris*, L. and H.); but, although neither described nor figured, we cannot venture to say that they have not been named, since M. Brongniart has, in his 'Prodrome' and his 'Tableau des Genres,' enumerated the names only of a considerable number of fossil Cycads, concerning which he has given us no further information. Without the opportunity of seeing authentic specimens, it is impossible to know what are the plants he intended by these names; so that any one undertaking to describe the apparently new species, would infallibly give new names to things already named in the 'Prodrome.' This has actually happened in the case of Brongniart's *Pterophyllum Williamsonis*, which is the very plant now well known as *Pt. comptum*. Under these circumstances, I avoid, for the present, undertaking the description of these plants.

In conclusion, I will take this opportunity of correcting an oversight in my memoir on the fossil plants of the Alpine Anthracite‡.

* Quart. Journ. Geol. Soc. vol. iii. p. 431. pl. 24. fig. 2, A, B, C.

† Geol. Yorksh. p. 148. pl. 8. f. 2, and p. 154. pl. 10. f. 5.

‡ Quart. Journ. Geol. Soc. vol. v. p. 130 *et seq.*

I stated (p. 134) that *none* of the plants of that deposit "have any close resemblance to those of the lias or the oolites." To this there is an exception in the case of the ***Pecopteris Beaumontii***, Brongn.*, which comes so near to ***P. Whitbiensis***, that Brongniart hesitates whether to consider it a distinct species. This single exception, however, does not invalidate the general reasoning on that very singular case.

EXPLANATION OF PLATES XII. AND XIII.

PLATE XII.

Fig. 1 *a*. *Sphenopteris nephrocarpa*; natural size.
Fig. 1 *b*. A leaflet of the same, showing the fructification at the extremities of the lobes.
Fig. 2. A fragment of a recent *Dicksonia* (*coniifolia*?), from New Granada, for comparison with Fig. 1.
Fig. 3. *Baiera ? gracilis*; natural size.

PLATE XIII.

Fig. 4 *a*. *Cryptomerites ? divaricatus*; natural size.
Fig. 4 *b*. A small portion of the same, magnified.
Fig. 5 *a*. *Pecopteris exilis*; a barren leaflet, magnified, showing the veins.
Fig. 5 *b*. The same; a fertile leaflet, magnified, showing the capsules.

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2. *Notice of the Occurrence of* Upright Calamites *near* Pictou, Nova Scotia. By J. W. Dawson, Esq.

[Communicated by Sir C. Lyell, F.G.S.]

In his 'Travels in North America†,' Sir C. Lyell notices the occurrence of Upright Calamites in the Upper Coal-formation near Pictou. At the time of his visit this bed was covered by the water of a mill-dam, and he notices it on my authority. In the past autumn a part of the dam was broken down by a freshet, and a few feet of the outcrop of the bed exposed. I availed myself of this opportunity to verify the observations which I had made several years ago, and was so fortunate as to find a group of the vertical stems in the exposed portion of the bed.

The beds at this place dip to the E.S.E. at an angle of 25°, and consist of grey argillaceous sandstones; the upper part being somewhat hard and flaggy, and the lower very fine-grained and soft. They belong to the upper portion of the Coal-formation, and are associated with brown sandstones and shales, grey sandstones, concretionary limestones, and conglomerates, all of which appear in the vicinity, and frequently contain remains of *Calamites*, *Artisia*, *Lepidodendron*, *Endogenites*?, and Ferns.

The stems of the vertical Calamites in the bed now under consideration are about 20 inches in length, and the largest is 1 inch in diameter. The larger stems are in their upper part at right angles to the beds; the smaller are more inclined, and are often broken off at a lower level than the larger stems.

* Hist. Veg. Foss. p. 323.

† (First Series), 1845, vol. ii. p. 195.

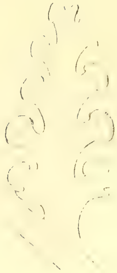

Fig. 1. b.

Fig. 2.

Fig. 1 a.

Fig. 3.

C. J. F. Bunbury, del.

Reeve & Nichols, lith.

Fig. 1. Sphenopteris nephrocarpa. Fig. 2. Dicksonia coniifolia (Recent).
Fig. 3. Baiera ? gracilis.

C. J. F. Bunbury, delt.

Reeve & Nichols, lith.

Fig. 4. Cryptomerites ? divaricatus
Fig. 5 Pecopteris exilis.

The tops of the larger individuals have not been removed by decay, but have been broken sharply off, presenting at the summit of the vertical part a crushed appearance, quite like that of a hollow cylinder of paper bent at right angles. The upper parts are flattened and compressed, and lie as if broken off by a force acting from the westward. I could not succeed in tracing any of them to the upper extremity of the plant. I found it quite easy, however, to trace the stems downward from the upper termination of the vertical part to the roots; although the cross fractures, caused by the bedding, rendered it impossible to extract perfect specimens. For about a foot below the point at which they are broken off, the stems are cylindrical, although some of them have bruises on their sides, as if hard substances had been drifted against them. Towards the base the stems bend in a somewhat spiral manner, as we often find to be the case with weak-stemmed herbaceous plants, and then rapidly diminish in size, terminating in a blunt point. They become of course somewhat flattened as they bend toward a horizontal position. The stems are arranged in groups which appear to spring from the same point. From an area of about two square feet I obtained portions of at least ten upright stems. The accompanying diagram, fig. 1, represents one of these groups, which I traced downward to the roots, and the individuals composing which were only from two to four inches apart. Fig. 2 is the upper part of one of the larger vertical stems, as it appears at the point where it has been broken off; and fig. 3 is the pointed lower extremity of another of the larger stems.

In the layers of rock, surrounding the vertical stems, are many prostrate, and a few inclined Calamites, a few fronds of Ferns, leaves of *Flabellaria*, and slender grass-like leaves, similar to those of some species

Fig. 1.—*Upright Calamites, near Pictou.*

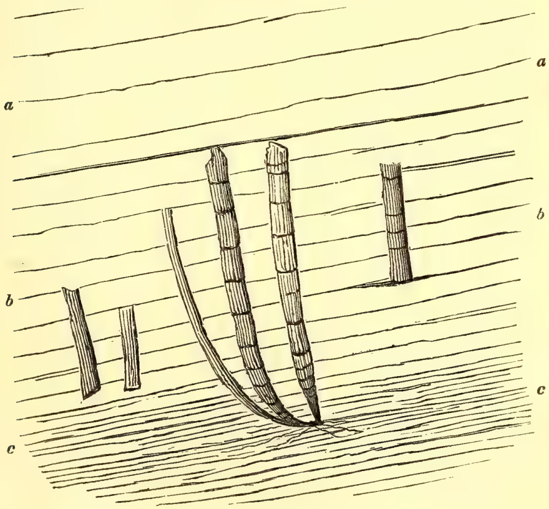

Fig. 2.

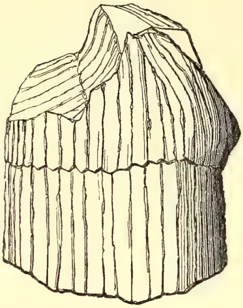

Fig. 3.

of *Lepidodendron*. No leaves are attached to any of the stems of Calamites. Around and below the bases of the stems there are numerous fibrous rootlets, and also some Fern-leaves and prostrate Calamites, and horizontal flattened stems having finer striæ than those of the species of Calamites occurring here. I endeavoured to ascertain if any one of these horizontal stems was connected with the Calamites in the manner of a Rhizoma, but I could find no distinct connection.

The occurrence of a single group of Calamites in this manner might be accounted for by supposing that they had been drifted from the land with their roots attached, and had thus settled and been buried in an upright position. It must, however, be borne in mind that formerly, before the erection of the present mill-dam, this bed could be traced for a considerable distance along a bare cliff, and everywhere contained vertical Calamites. It seems most probable, therefore, that a bed or thicket of Calamites grew on this spot, and were buried *in situ*. In this case they grew in soft alluvial mud, not especially rich in vegetable matter, perhaps covered by shallow water; and were buried by a more rapid accumulation of similar mud, gradually becoming coarser. In fig. 1, *a* denotes the upper and coarser beds, *b* the finer beds surrounding the stems, and *c* the still finer beds with rootlets at the bases of the stems. The sudden breaking off of the stems may not have been entirely owing to the greater force of the current or coarseness of the detritus. In a portion of the bed overlying the Calamites, not now exposed, I saw many years ago a prostrate *Lepidodendron* having its branches and leaves entire. Such drifted trees, if swept through the submerged Calamites, would easily break off their slender and fragile stems.

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3. *Further Remarks upon the* CALAMITE. By J. S. DAWES, Esq., F.G.S.

[*Abstract.*]

AFTER noticing the works of some foreign authors who had treated upon the Calamite prior to the date of his last communication*, and

* Read May 31, 1848. See Quart. Journ. of the Geol. Society, vol. v. p. 30.

with whose researches he was not then acquainted, Mr. Dawes states that, from the observations hitherto made, the Calamite appears to consist of a large central column of tissue, surrounded by a cylinder of woody structure. This central part, having commonly rotted away soon after the death of the plant, has been replaced by a mineral cast of the inside of the ligneous cylinder, and, owing to the general disappearance of the latter, the jointed and ribbed cast is the usual form in which the Calamite is presented to us in the carboniferous rocks*.

The outer ligneous surface appears also to have been ribbed, or rather marked with longitudinal *striæ*, more or less perfect, but without any indications of joints or constrictions†; the position, however, of these articulations is shown upon some specimens by the presence of small and somewhat oval verticillate leaf-scars, to which may have been appended leaves, corresponding to those attached to Brongniart's *Calamites radiatus*‡. These leaf-scars were connected with the small round or ovate processes, usually observed at the joints of the Calamite-cast, by large muriform rays, which passed horizontally through the outer cylinder of woody tissue. These processes have been formerly mistaken for the true leaf-scars of the plant§.

This outer woody layer is usually met with only in a carbonized state,—that is, in the shape of a thin coating of crystalline coal‖; but occasionally the structure has been met with well-preserved. It is composed of two distinct tissues, the one cellular, the other pseudo-vascular. In the transverse section these appear to be arranged in alternating vertical plates, which radiate from the inner aspect of this cylindrical woody layer to its periphery, and correspond with the ribs and furrows seen on the surface of the interior cast. These alternating plates, being of different shades of colour, are sufficiently visible to the unassisted eye¶.

The darker stripes, which constitute the pseudo-vascular part of the structure, arise in somewhat wedge-shaped masses from the centre of each furrow, and as this tissue diverges into the cellular part of the

* This fact was first distinctly shown by Germar in 1838, and in the same year by Corda, who pointed out that, in all probability, the stem was not originally hollow, but occupied by cellular tissue, which had subsequently altogether rotted out.

† This condition is seen in Unger's figures, published in the German translation of Petzholdt's work 'De Calamitis et Lithanthracibus.' It is also well shown upon specimens in the author's collection.

‡ Hist. Veg. Foss. pl. 26. figs. 1, 2.

§ Brongniart considered these processes to be simple tubercles, which had never been connected with any leafy or other appendage.

‖ Brongniart had, as early as 1828, observed specimens having this outer covering in a carbonized state; he also remarked that the ribbing was very indistinct, and that the articulations or joints were to be observed only beneath the coaly covering. So long as this outer covering had been met with only in the carbonized state, there was no proof, as Lindley and Hutton justly observed, 'Fossil Flora,' vol. i. p. xxx, that the coaly matter, thus found enveloping these fossils, was really the remains of a cortical integument, or formed any part of the original organization of the stem, for it might have been an independent carbonaceous formation.

¶ This arrangement of the tissues was regarded by Cotta as indicating medullary rays, which opinion Unger considered to be incorrect.

stem, a small portion of the parenchyma opposite each adjoining rib is usually left unpenetrated by the vascular fibre*. The lighter-coloured stripes are in fact merely portions of the cellular or parenchymatous structure which have not been so closely interwoven with the pseudo-vascular tissue, emanating from the furrows as before mentioned.

The darker-coloured tissue, when examined in the vertical section, is found to be marked with fine transverse *striæ*. This differs, however, from true scalariform structure, inasmuch as these peculiar markings, like the *areolæ* on the walls of the vascular tissues of the *Coniferæ*, are only to be detected when the sections are cut in the direction of the rays. Indeed these transverse striæ in some specimens are seen to become reticulate, as in the *Pinites* of the Coal-measures. Moreover, in a transverse section, the wood of the Calamite exhibits a network of quadrangular tissue, similar to what we observe in the *Coniferæ*.

The lighter-coloured tissue appears to be composed of elongated rectangular cells, exhibiting a general uniformity of size†, and, as these cells occur in nearly perpendicular and parallel rows, the terminal junctions of the cells, owing to this arrangement, give to the vertical slices, when the specimen is somewhat opaque, an appearance as though lines of tissue passed horizontally through the structure‡. If, however, as the author observes, a longitudinal slice of the fossil be cut in the direction of these lines, and reduced to merely a single cell in thickness, it will become evident that the lines in question have their origin in the peculiar form and arrangement of the cells of the parenchymatous tissue as above described. A somewhat similar appearance may be noticed in some specimens of *Halonia* and also in the *Sigillariæ*; indeed the more these fossils of the Coal-measures are compared together, the greater is the affinity met with in their structure. The author mentioned that, on lately examining a specimen of *Sigillaria reniformis*, the tissues appear so much to resemble those of the Calamite, as to prove the close connection of these two genera;—in fact all those fossils of this family with the broad outer zones of woody tissue, such as *Calamitea striata* of Cotta, will in all probability prove to be some species of small-ribbed *Sigillaria*. One other important point Mr. Dawes is enabled to prove, viz. that concentric rings not only do occur in these fossils, but that they are as clearly defined as in any recent dicotyledon§.

The interior of the Calamite appears, so far as can be ascertained,

* These small cellular spaces, being frequently roundish and pretty regular in size, were considered by Unger to represent aërial canals. See Unger's Memoir read at Erlingen and published by the Botanical Society of Ratisbon, Nos. 41, 42.

† Unger has described the lighter-coloured structure as pseudo-vascular, and the darker rays as the cellular tissue; which however is not correct.

‡ These linear appearances were described in the author's former paper as indicating medullary rays; and so also were they regarded by Unger; but of this circumstance Mr. Dawes was not previously aware.

§ The existence of these concentric zones of periodical growth has not been shown by any other observer; indeed Unger especially alludes to their absence, as a proof of the affinities of this plant with the *Equisetum*.

from the imperfect state of the specimens, to have been composed of lax cellular tissue, traversed by pseudo-vascular bundles, and to have been interrupted, at intervals corresponding to the joints, by horizontal plates of tissue (*Phragmata*), the horizontal striæ or radii upon which correspond with the ribbing upon the cast. These *Phragmata* usually present a larger or smaller ring at the centre*, as though perforated by a woody axis†. The author has in fact specimens of what he believes to represent this axis, which appears to have been traversed by a central cellular tissue, the true medulla of the plant. The wood of this axis also exhibits a reticulate structure, similar to that of *Pinites*.

With regard to the structural analogies that have been stated to exist between *Calamites* and *Equisetum*, the author remarks that the presumed existence of tubular passages, similar to the aërial canals of *Equiseta*, demand a short notice. Petzholdt considered that the sections of some specimens he had examined, and which retained the remains of a carbonized woody structure, afforded evidence of two sets of aërial canals, similar to those observed in transverse sections of the stem of *Equiseta*. Mr. Dawes, however, observes, that both the roundish and triangular spaces, referred to and figured by Petzholdt, are evidently the result of the decay of the parenchymatous tissue and a bulging of the vascular plates, the regular arrangement of which gave rise to a more or less regular series of these accidental spaces, as seen in the transverse sections of the stem‡.

In conclusion, the author observes, that there are still many doubtful points in the structure of these interesting fossils which can only be cleared up by the discovery of more perfect specimens; he considers, however, that although the Calamite appears to have had no structure that can in any way unite it with the *Equisetaceæ*, nevertheless some portions of its tissues must be considered as having Acrogenous characters; whilst the rectangular cells of at least a part of the parenchymatous tissue, being arranged in perpendicular series, is a character more commonly met with in Endogens; and, at the same time, there is sufficient evidence of Gymnospermous affinities, together with the presence of well-defined concentric rings, so characteristic both of this family and of other Exogens.

* This appearance is seen in the specimen figured under the name of *Calamitea bistriata* (see Die Dendrolithen in Beziehung, &c., Taf. 15), which evidently represents merely a *Phragma* of the plant, and not the woody structure, as Cotta had supposed it to be.

† The probability of the existence of such an axis was, the author observes, suggested by Dr. Petzholdt.

‡ The specimens described by Dr. Petzholdt were met with at Gittersee, near Dresden. They seem to have been much distorted, and the woody cylinder is described as being in a carbonized state, and appears to have exhibited very imperfect traces of structure.

March 26, 1851.

John Kirkpatrick, Esq., and George Whitmore, Esq., were elected Fellows.

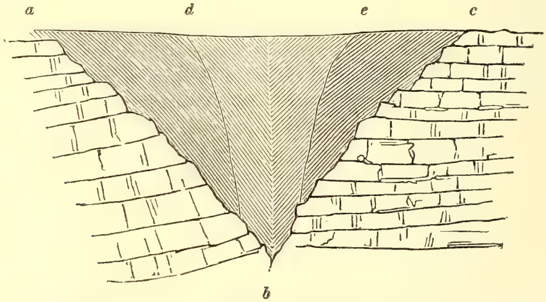
The following communications were read:—

1. *On the* Till *of* Caithness. By John Cleghorn, Esq.

[Communicated by Sir Charles Lyell, F.G.S.]

[*Abstract.*]

The Till generally occupies the low districts of Caithness. At Lybster, however, fourteen miles south of Wick, it reaches 212 feet above the sea, with an unascertained depth below low-water mark. In the harbour it has been bored twenty feet, and it is the anchorage ground of the bay. The author finds that at Lybster and at Wick the deposit is in a trough of rock, more than a mile broad and many miles long, of the shape seen at *a, b, c,* in the annexed woodcut. At Lybster the deposit is cut through by the Burn of Reisgill, which empties itself into the harbour, and at Wick by the river of Wick; at both places the clay is found on each side of the watercourses, rising in high banks, as shown at *a, d,* and *e, c,* in the accompanying diagram.



From observations Mr. Cleghorn has had the opportunity of making, he believes the Till to be laminated, as represented in the accompanying section, and that the troughs at Lybster and Wick, previously to the denuding action of the Burn and the River, were filled up as represented in the figure.

From the position of the Till in Caithness, its lamination, and broken shells, from the occurrence of smoothed and scratched boulders in the Till similar to such as are found in the watercourses near Wick, and from the apparent elevation of the Caithness coast-line, as proved by the occurrence of rocks perforated by lithodomous molluscs at various elevations above the present level*, the author

* This communication was accompanied by several slabs of micaceous limestone covered by shallow pittings caused by marine molluscs (*Patellæ*) and weather-worn in various degrees, which Mr. Cleghorn obtained at different heights above the present sea-level.

infers that the Till is the wastings of coasts and the sedimentary matter of rivers deposited in the valleys of a deep sea, inhabited by the *Anarrhicas lupus**.

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2. *On the* Erratic Tertiaries *bordering the* Penine Chain, *between* Congleton *and* Macclesfield; *and on the* Scratched Detritus *of the* Till. By Joshua Trimmer, Esq., F.G.S.

The dispersion of granitic and other northern detritus over the plain of the New Red Sandstone in Lancashire, Cheshire, Staffordshire, Shropshire, and Worcestershire, and the presence of marine shells in the erratic deposits of that district are now so well known, that notice of their occurrence in any new localities within it can have little interest, except as illustrating general views respecting the history of these deposits, their influence on the distribution of soils, and the origin of their peculiar characters. I refer to the Proceedings of the Geological Society, vol. i. p. 419, to the Journal of the Geological Society of Dublin, vol. iii. part 4, and to the Report of the Newcastle Meeting of the British Association, 1838, for descriptions of the Upper and Lower Erratics (then called Diluvium and Northern Drift) between the Mersey and the Dee, and along the western flanks of the Welsh mountains, from the Dee to Harlech; and also for evidence of the accumulation of the erratic deposits on a previous terrestrial surface on the western, similar to those exhibited on the eastern side of the island by the Cromer sections.

The proofs consist in the superposition of the marine deposits in Cefn Cave on the banks of the Elwy in Denbighshire to those containing mammalian remains, and to mammalian remains and timber in the detrital lead-works of Talargoch, at the mouth of the Clwyd, of which the Elwy is a tributary At the latter locality, they are accompanied by whole marine shells, with numerous pebbles of limestone abounding with molluscous perforations, the absence of which, from the erratic deposits, even when full of limestone fragments, constitutes one of their characteristics.

Notice of the mammalian remains at Talargoch will also be found in the 'Reliquiæ Diluvianæ' (p. 178); and the deposits of Cefn Cave, with the exception of the marine bed, were also described by the late Bishop of Norwich in the Proceedings of the Geological Society, vol. i. p. 402.

I shall now show, that the erratic deposits of the western coast extend into the interior, where they are of great thickness, and that the divisions† of "Lower Erratics," "Boulder Clay," and "Upper Erratics" (sand and gravel) are persistent to the very edge of the Penine Chain, modified by the exceptional circumstance of a bed of sand with

* See Quart. Journ. Geol. Soc. vol. vi. p. 386. The Cat-fish, here referred to, reduces the shells of Molluscs on which it feeds to coarse fragments, and, after digesting the soft parts, emits the fragments [by regurgitation].

† Journal of the Royal Agricultural Society, vol. vi. part 2. pp. 461 *et seq.*; and Quart. Journ. Geol. Soc. (No. 25) vol. vii. p. 21. par. 4.

erratic detritus, about twenty feet thick, interposed between the rock and the clay, and similar to the sand above the clay.

A large portion of the materials, both of the sand and clay, have been derived from the strata of the New Red, mixed with detritus from the Carboniferous hills on the east, as well as with a great abundance and variety of granitic and slaty fragments, transported from the north.

The larger northern boulders appear to belong chiefly to the Upper Sand, but are occasionally found in the Till. This consists of a red clay, containing many small fragments having a northern origin, and much detritus derived from the neighbouring chain.

I have seen shells in the erratic deposits at four points; namely, in a sand-pit of the Upper Erratics, about three miles north of Macclesfield, on the Stockport road,—about two miles south of Macclesfield in gravelly clay, evidently derived from an adjoining cutting,—in the same kind of deposit in a cutting at the Northrode Station four miles, and in a pit by the Dane Viaduct six miles, south of Macclesfield. The shells were in the state of finely comminuted fragments in the sand-pit on the Stockport road. At the other spots, although still small, they were of sufficient size to permit the recognition of the genera *Turritella* and *Cardium*.

In this district, as in others which I have examined on the eastern coast, in Wales, and in Ireland, the variations of soil are dependent on the amount of denudation to which the Erratic Tertiaries have been subjected, and on the depth and composition of the unconformable deposit, or "warp," thrown down on this denuded surface. By reference to the Ordnance map, it will be seen, that a tract of very broken ground extends from Alderley Park, by Capesthorn, to Sidlington and Gawsworth. The numerous hillocks with which the tract is studded are caused by the partial denudation of a ridge of the Upper Sands. Though light soils predominate, this district affords every variety from sand to clay, the sandy soils being chiefly on the summits and steep sides of the hillocks, and the clay in the valleys between them, in which latter the denuding process has reached the Till. The loams, varying in depth and in the proportion of the aluminous matter contained in them, are spread over the long slopes. The general distribution of sand and clay, dependent chiefly on the Erratic Deposits, is shown, as well as it can be on so small a scale, on the map accompanying Dr. Holland's Report on Cheshire to the Board of Agriculture.

On the eastern skirts of Macclesfield, the superposition of these sands to the Till is well exhibited. For about four miles south of that town, the Macclesfield canal runs along the upper surface of the Till in a valley, where the Upper Erratics have been much denuded, between the ridge of sand and the carboniferous hills. At a place called Bullgate the canal makes a descent, by twelve locks, which cannot be less than 120 feet; and then runs for a mile, first along a terrace of reconstructed gravel, and then on reddish sand, resting in some places on red marl, in others on dark coal-shales.

The rocks beneath these deposits appear to have a very irregular surface. At the aqueduct by which the canal crosses the Dane about ten feet of black shale are visible, covered by five or six feet of coarse reconstructed gravel, much rolled, which has been derived from the materials of the denuded Till and Upper Erratics. On the same left bank of the river, about a quarter of a mile lower down the stream, we have about forty feet of black shale, covered by about twelve feet of reddish sand and seven feet of reconstructed erratic gravel. At Colley's Mill, nearly opposite, red marl is exposed in the bed of a tributary of the Dane; and a quarter of a mile further down, on the left bank, it forms a cliff about sixty feet high.

The road from Leek to Congleton for the last mile descends, first about twenty or thirty feet, over some rounded hills of sand, to a level tract, covered with rolled and reconstructed erratic gravel, on which Buglawton stands. There are two other descents, of twenty feet each, to two similar level tracts or terraces, the lowest of which consists of loam with many large pebbles, both local and erratic. Another fall of twenty feet reaches an alluvial deposit of loam upon gravel, about seven feet above the level of the present stream.

At Congleton, on the right bank, is a cliff about ninety feet high, the upper twenty or thirty of which consist of reddish sand with granitic and other foreign small detritus. Red clay, with scratched fragments (Till), is seen to rest on this sand in the brick-field about halfway between the bridge at Congleton and the junction of the Macclesfield and Stockport roads. From this point, we have a clay subsoil between the two roads for about two miles, covered either by a sandy soil, or a mixture of the sand of the Upper with the clay of the Lower Erratics.

At Cheney Gate, hillocks of the Upper Sands commence, and continue to Macclesfield. In descending from Cheney Gate to Northrode Station the same succession of deposits is crossed—first sand, then clay, down to the railway. At the Station a cutting fifteen feet deep has been made in the Till, which is full of small gravel and contains many fragments of shells. It passes down, as shown by a well that was being sunk at the time of my examination, into a fine red clay, with a very few pebbles and fragments of shells. Beneath this clay, which is twelve feet thick, is reddish sand, which one of the railway workmen informed me they had penetrated to the depth of ten feet without reaching the bottom.

Similar pure red clay, beneath red gravelly clay, occurs in the brick-field at Fodenbank near Macclesfield, where the base of it is not exposed. I have found no shells in this Lower Sand. Sir P. Egerton has described* a bed of pebbly sand, at least thirty-six feet deep, at "the Willington" near Tarporley, Cheshire, about twenty-five miles west of Macclesfield, containing marine shells. It was "separated, by a well-defined line, from an overlying deposit, twenty feet thick, of the ordinary diluvium of Cheshire, containing pebbles and boulders of granite, slate, greenstone, and other rocks." This diluvium consisted chiefly of sand. From the low level, seventy feet above the Mersey, it is probably reconstructed. If the shelly gravel of Wil-

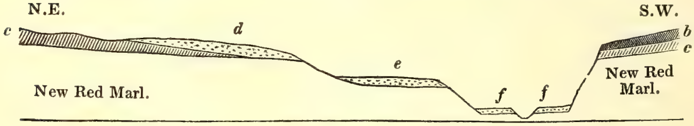
* Proc. Geol. Soc. vol. ii. p. 189.

mington can be traced under the Till, which we know to be abundant in that vicinity, it would offer phænomena analogous to the marine bed of which there are traces at Runton, in Norfolk, above the freshwater beds*, indicating the existence of ordinary marine conditions at the commencement of the submergence, before the setting in of the peculiar agencies which produced the Till†.

The accompanying diagram, fig. 1, represents the successive terraces of reconstructed erratic materials, on the banks of the river at Congleton, and the cliff of red marl and erratic tertiaries on the right bank. Fig. 2 represents the succession of erratic deposits from the cliff at Congleton to Alderley Edge.

Fig. 1.—*Section across the Valley of the Dane from Congleton to Buglawton.*

Horizontal scale 1 mile to 2 inches. Vertical scale 240 feet to 1 inch.



b. Lower Erratics. Till.
c. Thin bed of sand, sometimes gravelly.
d, e, f, f. Reconstructed gravel.

North of Alderley Edge to Stockport, the surface is chiefly clay, varied by outliers of the Upper Sands, and by accumulations of reconstructed erratic materials, which border the line of the Bolling, at various levels. At Stockport the Mersey has cut a channel, twenty feet deep, in sandstone of the New Red. The higher parts of Stockport appear to stand on sand, resting on clay which has sand between it and the rock. In the lower ground, along the line of the railway to Manchester, the surface is chiefly a clayey loam, which, in the brickfields at Manchester, passes down into a very tenacious Till, with much fragmentary limestone. On the higher grounds about Manchester, as at Cheetham Hill, are outliers of sand resting on Till.

In no part of the lines of railway from Alderley to Manchester, and from Congleton to Stockport, are there cuttings which now exhibit the stratification to a greater depth than thirty feet; and in none have I observed the rock. From a combination of all the sections observed with the estimated height of the hills of erratic deposits which rise above them, I cannot estimate the depth of these deposits at less than 150 feet, of which about 50 may consist of Till.

Scratched Detritus of the Till.

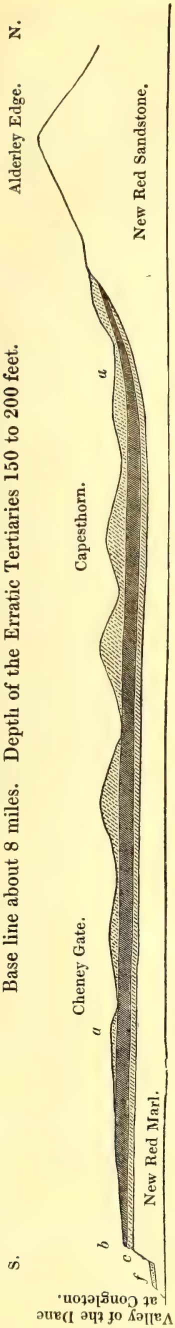
In the Upper Erratics of the different districts which I have at various times examined, I have seen deep scorings on some of the large blocks, particularly the local blocks; but I believe that the

* Quart. Journ. Geol. Soc. vol. vii. p. 20. par. 2.

† See also Quart. Journ. Geol. Soc. vol. vi. p. 386, for notices by Mr. Smith of Jordan Hill of exceptional cases of sand with shells below the Till.

Fig. 2.—*Section from Congleton to Alderley Edge.*

Base line about 8 miles. Depth of the Erratic Tertiaries 150 to 200 feet.



a, a. Upper Erratics. Sand and gravel. *c.* Thin bed of sand, sometimes gravelly.
b. Lower Erratics. Till. *f.* Reconstructed gravel.

small scratched detritus is characteristic of the Lower deposit, or Till. I have not observed an instance of it in the Upper Erratics, either of the east or west of England. From recent observations, I doubt whether these scratches are found on the smaller fragments of granitic and other northern rocks in the Till itself, which have been derived from great distances, and whether they are not confined to such as have come from the neighbouring high grounds. Should this prove to be the case generally, it would throw much light on the history of these deposits, if we could determine the exact nature of the agencies by which the polishing and scratching of these fragments were effected, whether they are to be referred to the action of marine, or of terrestrial ice. When slabs of slate are found, as I have seen them in the valleys of the interior of Wales, with one side polished and scratched, the other remaining quite sharp, we can have no difficulty in supposing the upper surface to have been protected, by being fixed in a mass of ice. When both sides have been polished and scratched as in the specimen of limestone from the Till at Manchester, now exhibited to the Society (see fig. 3, page 207), it may be supposed, that, having been imbedded in ice, its under-surface was scratched in passing over hard points, and that, having been frozen-in during another season in a reversed position, the same process was repeated on the opposite side. It is objected, that, if the ice were shore-ice, the first set of scratches would be effaced by the action of the sea on the beach before the stone could be again enveloped in ice. It may be supposed, on the other hand, that, the stone being stationary, the ice, having small gravel and sand frozen into it, passed over the stone, polishing and scratching the upper surface; and that, the position of the stone having been reversed, the opposite side was subsequently subjected to the same action.

The Narratives of the Polar Voyages furnish many facts illustrative of the manner in which fragments of this kind might be imbedded, under an arctic climate, in a littoral deposit of mud.

In the first place, we have frequent notices of large surfaces covered to the depth of two feet by angular fragments which the frost had detached from the rock (limestone) lying beneath,—of innumerable blocks of limestone constantly detached from an adjoining precipice and rolling down slopes,—of ground covered for the space of a mile with small pieces of slaty limestone, the cliffs in many places resembling ruined battlements, from which fragments were continually falling. We have notices also of pillars of rock rising like stacks of chimneys and surrounded with masses of their debris. These last may be compared to the peaks of bare rock, surrounded by great heaps of their own angular blocks, so common on the summits of the Welsh mountains.

Secondly, on the melting of the snow, during the short arctic summer, the ravines are filled with furious torrents which hurry much detritus into the sea. Where the land is high, the greater accumulation of snow furnishes a constant supply of water during the whole summer; but where it is low, it soon becomes free from snow, the ravines entirely dry, and the whole face of the ground parched and cracked, as if there had been no moisture on it for a long time.

The detritus thus hurled into the sea produces points of land at the mouths of the ravines. This is so invariable a fact, that Sir E. Parry declares that "in case of danger from the sudden closing of the ice, a ship may always be sure of meeting with one of these points, which are too small to be seen at a distance or delineated on the chart, by steering for one of the ravines, the latter being distinguishable several miles from the land."

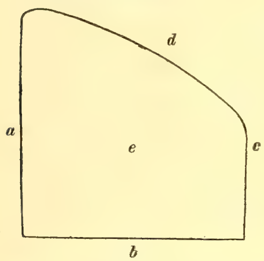
Lastly, it was observed that in the beginning of the summer, the snow, when partially melted, freezes again into a thin cake of ice. In some seasons and in some situations, this appears to be the extreme limit of the thawing process; certain cliffs which, when visited at one season, were clear of snow, were found at the close of another colder summer covered by a layer of blue transparent ice, the result of the partial thawing of the snow, arrested by the frost.

Such conditions would be particularly favourable to the enveloping of detritus in ice, to its sliding down slopes thus enveloped, and to its final transport to the sea. It might slide down slopes, and be floated over level surfaces. It might make the journey to the coast, by successive stages, during several seasons; and at each halt scratches previously received would, upon the land, be safe from that obliteration, which it is objected must take place upon the sea-shore. At each stage of its journey it might present a different surface to the polishing and scratching action; and at length, still imbedded in ice, it might reach one of those violent and transient torrents, by which it might be floated out to sea and dropped, on the melting of the ice, into the mud in the condition of the specimen exhibited at the Meeting (see fig. 3).

From these considerations, the accordance of the state and distribution of the fragmentary matter in the Till of Norfolk and Wales with the observed effects of marine and atmospheric action under an arctic climate was inferred in the paper alluded to in a former communication *, written in 1847, for the Memoirs of the Geological Survey of Great Britain. From this paper, although not yet published, I take the liberty of making the following extract:—

"By the melting and fracture of the ice, the detritus would be deposited under a great variety of conditions. Here we should have great heaps of Kimmeridge clay, containing many tons weight, shot down by the side of equally large heaps of unmixed chalk. There the two would be blended together in smaller masses. As the melting ice drifted about, much of this clay and chalk would be deposited as separate fragments, water-worn by the wash of the sea over the ice. The ice would have received part of the detritus in that state; and we should also find fragments buried in the mud, often retaining scratches which their lower side had received when sliding, set in ice, down the steep slopes of their native rocks, or which stranding ice-floes had impressed on their upper surfaces when grinding over them on the shore."

Fig. 3.—*Outline of a Boulder from the Till of Manchester, bearing scratches on most of its surfaces.*



The fragment of limestone, above referred to, page 205, from the Till of Manchester, is of the shape represented in fig. 3. The dimensions are, length of the side *a* $5\frac{1}{2}$ inches, of *b* $5\frac{1}{2}$, of *c* 3 inches. Thickness of the side *a* 3 inches, thinning off on the sides *c* and *d* to $1\frac{1}{2}$ and $1\frac{1}{4}$ inch. The face *e* and the opposite face are the most polished and scratched; the scratches are inclined to one another at various angles, which are greater on one face than on the other. The faces at *a* and *c* are slightly polished and scratched; the face at *b* is rough, without a scratch; and that at *d* rough, with a few scratches.

The greater proportion of the specimens of scratched detritus, sent to the Museum from various localities by different observers, exhibit similar conditions of form and of partial polishing and scratching on more than one side.

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3. *On the* Sequence *of* Events *during the* Pleistocene Period, *as evinced by the* Superficial Accumulations *and* Surface-markings *of* North Wales. By Prof. A. C. Ramsay, F.G.S.

[The publication of this Paper is deferred, by permission of the Council.]

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* Quart. Journ. Geol. Soc. vol. vii. p. 20.

April 9, 1851.

The following communications were read:—

1. *On the* Basement Beds *of the* Inferior Oolite *in* Gloucestershire. By the Rev. P. B. Brodie, M.A., F.G.S.

The lower strata of the Inferior Oolite, near Cheltenham, and in other parts of Gloucestershire, present some features of novelty and interest, which I now proceed to lay before the Society; and this will form a conclusion to my previous paper on the superior Divisions of this Formation*. The bed immediately below the "shelly freestone" has been correctly termed Pisolite or Pea-grit in the 'Geology of Cheltenham†,' and is there described as being "made up of small flat concretions from a quarter to half an inch in diameter, which give it the appearance of a nummulitic rock." At Leckhampton Hill it admits of the following subdivisions:—

		Feet.
1. Pisolite.	A.—Rubbly, coarse, pisolitic Oolite, the flat concretions rather large; in places much broken up, though some large blocks occur at intervals; prevailing colours yellow and brown. It contains some Corals and several species of *Echinodermata*, among which *Pygaster semisulcatus*, Phill. (*Clypeus ornatus*, Buckman) and *Hyboclypeus agariciformis*, Forbes, are characteristic	11
	B.—Hard, whitish, compact Oolite, called "Weatherstone" by the workmen; the flat concretions somewhat smaller than the above. It is a good useful stone, and stands the frost. Many beautiful Corals are scattered over the surface of the blocks	8
	C.—Coarse, concretionary, ferruginous Pisolite, with very large grains; a loose rubbly bed, like No. 1; Shells and Corals numerous; passing into a hard rough Oolite, less pisolitic in its structure than any of the above; varying in colour, brown and yellow predominating; fragments of *Trichites*, *Terebratula simplex*‡, *T. plicata*, *T. tetrahedra*, *Trigonia*, *Pectines*, *Amphidesma*, and other fossils abundant, and occasionally claws of Crabs§	19
	Total	38

* Quart. Journ. Geol. Soc. vol. vi. p. 239 *et seq.*

A description of the new species of shells in the "shelly freestone" is given in Mr. Lycett's valuable paper in the Annals of Natural History, vol. vi. No. 36, for December 1850.

I scarcely did justice to my friend Professor Buckman in my late communication upon the "shelly freestone," for I inadvertently omitted to state that he had previously remarked the identity of some of the *Testacea* with Great Oolite species, although the number referred to was at that time very small (see Geology of Cheltenham, p. 31).

† Outline of the Geology of the Neighbourhood of Cheltenham, by R. I. Murchison, 2nd edit. Augmented and revised by James Buckman and H. E. Strickland. 8vo. 1845, pp. 26 and 31.

‡ *Terebratula plicata* and *T. simplex* are most prevalent in the Pisolite, and do not occur below it; the latter is often of large size.

§ A new form of the minute Brachiopod, *Thecidea*, occurs in the Pisolite, which Mr. Davidson considers to be a variety of *Th. triangularis*, D'Orb. and Dav.; the latter is frequently found attached to Corals in the Oolite-marl. Several other new species of shells have been discovered in the Pisolite (especially by my friend Dr. Wright), but they are at present unnamed.

The same characters are presented by the Pisolite at Cleeve on the north-east, and at Crickley on the south, where it admits of the same subdivisions and contains identical fossils, although its average thickness is probably rather more*. South of Birdlip and along the more south-western range of the Cotswolds, the Pisolite disappears, but its absence is more than compensated for by the increased thickness of the Ammonitiferous oolite and inferior sands, the latter of which at Wotton-under-Edge are estimated by Mr. Lycett to be about 40 feet thick, and near Minchinhampton to average from 35 to 40 feet; while up the Chalford valley they are reduced (he says) to less than half that amount, and they probably thin out northwards where they are succeeded by the Pisolite. The next strata between the sands and the Pisolite, which constitute the lowest of the Inferior Oolite round Cheltenham, have not been previously noticed, or have been erroneously classed with the Pisolite, to which they obviously do not belong; one portion being especially interesting as forming a *bone-bed*, although of limited extent and thickness.

		Feet.	In.
2. Ammonite and Belemnite Bed.	D.—Immediately below C. of the Pisolite is a ferruginous Oolite, made up of small, brown, oval, shining grains like small seeds, cemented together by a sort of calcareous paste of a yellow and brown colour. It is characterized by *Belemnites* and *Ostreæ* ...	3	0
	E.—Yellow sand without fossils ...	0	1½
	F.—Hard, dark grey, approaching to brown, shelly, crystalline limestone containing *Belemnites*, some *Ammonites*, *Pectines* (*P. lens*), *Terebratulæ* (especially *T. bidens*), *Lima*, *Amphidesma*, *Gervillia*, and *Serpulæ*. Bones, Scales, Coprolites, and Teeth of Fish are dispersed throughout the mass, and may be most readily distinguished on the surface, intermixed with the same brown oval grains as in D. higher up. The Limestone has been bored into by *Lithodomi*, and the cavities are often filled up with fragments of bones, &c. At its junction with the sand, E. above, it is of a yellow colour, and it passes into a yellow, ferruginous, pure, sandy, micaceous stone, with fewer oval particles, full of *Belemnites*, *Ammonites*, *Pectines*, and numerous fragments of Bones, Scales, and Coprolites. On the whole, *Belemnites* are more abundant than *Ammonites* at Leckhampton ...	1	0
3.	Brick-coloured and dark yellow sandy marl, with broken Shells, chiefly Pectens, and small spines of *Cidaris*...	0	3
4.—	Blue micaceous shale (Upper Lias).		

At this particular spot†, the junction of the Oolite and Lias is well exposed; but, with the exception of Crickley Hill, this is the only locality along the whole line of the outer escarpment of the Cotswolds where it may be observed, owing to the quantity of debris and rubble which covers the slopes of these hills. Hence it is almost impossible to trace these lowest beds with any degree of accuracy, although it is evident that throughout the whole of the line, from Cleeve to Wotton

* The Pisolite extends, in all probability, in a north-easterly direction towards Winchcomb. The Oolite marl occurs there and at Chipping Campden, on the north-eastern extremity of Gloucestershire, with the usual characteristic fossils. At the latter place, my friend Mr. Gavey informs me that the freestone rests immediately upon the Lias; so that the Pisolite is entirely wanting. At present, however, our information of the Oolitic series in that district is very scanty, but I trust his zeal will soon remedy this deficiency.

† The junction of the Oolite and Lias is seen in a corner of the lowest quarry where sand is obtained, looking towards the north-west.

and Dundry, the "Ammonite and Belemnite bed" *underlies* the Pisolite, or *overlies* the sands, and is a very constant and well-marked member of the series. At Cleeve I detected just above the Upper Lias, some loose fragments of a hard, brown, sandy stone, with Shells, Bones, and Coprolites, which no doubt is present *in situ,* if it could be clearly ascertained. At Crickley the Pisolite, on the southern escarpment, reposes on a grey, bluish-brown, gritty stone, three or four feet thick, passing into a hard, grey, ferruginous rock, one foot thick. Fragments of Bones, Scales, Coprolites, and Teeth of *Hybodus* are very abundant, especially in the upper part; the shining, oolitic, oval grains are not so constant, but there are numerous *Belemnites, Ammonites, Pectines, Terebratulæ* (*T. bidens,* Phill.), large *Pholadomya, Spondylus* (*Hinnites*), &c. From the mass of debris the section is difficult to make out, but it is evidently a continuation of the same stratum at Leckhampton before described; the lithological differences are comparatively slight (the limestone, No. 2, F., being less clearly defined), and the zoological agreement nearly perfect. A roadside escarpment on Frocester Hill, facing the Severn, towards Coaley, presents the following section in descending order:—

		Feet.	In.
1.	Freestone (base of), the top beds shelly and flaggy, like the "shelly freestone" at Leckhampton, the lower part generally softer, coarser, and gritty; here and there traversed by hard shelly layers; the surface of the blocks often covered with broken stems of a new species of *Pentacrinites,* plates of *Cidaris,* and small water-worn Corals. It is used for building purposes, and is remarkable for its dazzling whiteness. These constitute the lowest beds of the freestone and are about 40 feet thick, the thickest portion forming the summit of the hill, and being on the whole quite as thick as at Leckhampton, which with some slight mineralogical difference it clearly represents	40	0
2.	Fine-grained gritty stone of a light brown colour, resembling the "Trigonia-grit," loaded with *Pholadomya, Trichites, Modiola plicata,* Sow., *Serpula socialis,* Goldf., and frond of a Fern, a rare fossil in the Inferior Oolite of Gloucestershire........ 3 or	4	0
3.	—Hard, yellow Oolite with few fossils	5	0
4. Ammonite and Belemnite Bed.	D.—Coarse Oolite, of a brown and yellow tint, made up of oval oolitic particles; full of *Belemnites**, *Ammonites* (*A. discoides,* D'Orbigny, *A. excavatus,* Sow., *A. Parkinsoni,* var. Sow.), large *Nautili, Modiola plicata,* Sow., *Astarte,* and numerous other shells. *Terebratula bidens,* Phill., occurs in layers at the top	4	0
	F.—Loose rubbly bed, with irregular nodules of a hard micaceous stone; the surface covered with *Serpulæ,* and occasionally bored into by a lithodomous Mollusk as the equivalent limestone at Leckhampton (see No. 2. F.); passing into a hard coarse Oolite, similar to D. above described, yielding *Belemnites, Ammonites,* and carbonized Wood. It becomes sandy at the base. I could detect no remains of Fish in any part, but it is evident that this entire band is identical with No. 2. at Leckhampton and Crickley, with which it agrees in most particulars	0	7
5.	Yellow micaceous sand; depth uncertain, but it must be of considerable thickness, probably 30 or 40 feet. Dip slight, to the south-east. The Lias is not well exposed in this section, although it is visible near the turnpike at the bottom of the hill, on the road to Frocester.		

* The greater number of the *Belemnites* and *Ammonites* from this division in the Cotswolds are unnamed.

In my former paper in the Quarterly Geological Journal, the group below the Pisolite was named the "Ammonite and Belemnite bed*," for the preponderance of these shells, independent of any other characters, distinguishes it from all others in the series. On the whole, these genera are comparatively rare in any of the superior divisions, and occur in greater or less profusion in the equivalent strata at Painswick, Beacon Hill, Haresfield, Frocester, Wotton-under-Edge, and Dundry. In all cases it may be also identified by the presence of the small shining oolitic grains, cemented by a brown or white calcareous paste. The remains of Fish appear to be merely local, for I have not observed them in any of the localities above-mentioned. With the exception of a few large Palatal teeth in the Pisolite, any traces of Fish are seldom met with in the Inferior Oolite of Gloucestershire, and their abundance in the present instance is a remarkable exception to the general rule. The bones, scales, coprolites, and teeth are very minute, rolled, and fragmentary, but in sufficient numbers to form a kind of *Bone-bed*, and probably belong to more than one species of Fish, and I have only noticed one which could be ascribed to Saurians. Teeth are not common; the few which have been discovered were pronounced by Sir P. Egerton to belong to a species of *Hybodus*. The great profusion of certain genera of Cephalopods, such as *Ammonites, Nautili*, and *Belemnites*, indicates a deep sea, which evidently became shallower during the deposition of the shelly freestone, and even in some degree before the Pisolite; an inference which may be drawn from the presence of *Lithodomi*. The evidence afforded by the occurrence of a boring Mollusk is that of partial elevation and repose; but, as *Ammonites* and *Belemnites* are again found a little higher up, there must have been another local subsidence; *after* which, and *before* the formation of the freestone, the sea would seem to have been getting gradually shallower; for the general character both of the Pisolite and freestone points to an ocean of less depth than that in which the Ammonite-bed† was deposited.

It is a curious and interesting fact, that, in nearly every example, the large fragmentary accumulations of the remains of Fish or Saurians, commonly called "bone-beds," have taken place at the close of one formation and the commencement of another; and it is not perhaps easy to assign a reason for this coincidence, although most of these peculiar deposits are only local and not very extensive, the Lias

* When I spoke of this stratum near Cheltenham (Quart. Journ. Geol. Soc. vol. vi. p. 224, note) as being a diminished representative of its equivalent at Frocester, I referred more especially to the increased thickness of the sands beneath, which at Leckhampton are barely represented by three inches of sandy marl; the *Ammonite and Belemnite bed* itself being of uniform thickness, or nearly so, at both those places, but expanding considerably at Wotton and Dundry.

† Mr. J. C. Nesbitt has kindly examined some portions of this rock, and informs me, that although he has not yet had leisure to make an accurate quantitative analysis, yet, from qualitative experiments, he feels satisfied that the specimens he examined, viz. a cast of a small Ammonite and hand-specimens with many small fragments of bones, &c., from this basement-bed of the Inferior Oolite, contain between 40 and 50 per cent. of phosphate of lime;—in fact, that the whole of the specimens are highly phosphatic.

"bone-bed" being the thickest and most widely distributed. The following well-known examples will point this out:—

Bone-bed at the base of the Lower Greensand at its junction with the Wealden.

Bone-bed at the base of the Inferior Oolite at its junction with the Lias.

Bone-bed at the base of the Lias at its junction with the New Red Marl.

Bone-bed at the base of the Mountain Limestone at its junction with the Old Red Sandstone.

Bone-bed at the base of the Old Red Sandstone at its junction with the Ludlow Rock*.

If the Lias bone-bed be correctly assigned to the Trias, it would then mark the commencement of the New Red Sandstone epoch, instead of the close of the Liassic.

I am indebted to my friend Mr. Lycett for some useful information respecting the Lower Division of the Inferior Oolite in his own district, and with which indeed he is in all respects so well acquainted.

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2. *On some Points of the* Physical Geography *of* North America *in connection with its* Geological Structure. By Sir John Richardson, M.D., F.R.S.

[Communicated by Sir C. Lyell, F.G.S.]

In the following brief communication it is my purpose to draw the attention of the Society to the remarkable connexion that exists between the river- and lake-basins of North America and the geological structure of that region.

An inspection of Arrowsmith's or any other good general map of the continent will show, that to the east of the Rocky Mountain chain the chains of great lakes or the river-valleys have either a parallelism to the Rocky Mountains, or run nearly at right angles thereto. North of the St. Lawrence basin all the greater excavations lie in a line parallel to the axis of the Rocky Mountains, and at the junction of Silurian strata with a granitic formation, while narrower valleys, occupied by the greater rivers, cross them nearly at right angles. A few explanatory observations will make this more clear.

The Rocky Mountain chain has a general course for 2500 miles, or from the 30th parallel of latitude to the Arctic Sea, of North 26° West; that is, of about North-west by North. Its peaks rise from 12,000 to 15,000 feet above the sea, but passes occur at various places at elevations of from 6000 to 8000 feet. The higher parts of the range rise abruptly, but along the eastern base of the chain there exists a belt, composed chiefly of sandstone, 150 miles wide, which has a mean inclination of thirty-six feet in the mile, in its descent from 8000 feet to 2500. From this belt to the shores of the Atlantic, a distance of about 1800 geographical miles, the descent

* See Sil. System, pp. 198–200.

averages a little more than a foot in the mile. Six hundred miles of the western part of this slope is nearly regular in its descent, being what is named "prairie land," or "rolling prairie,"—the rest is variously excavated.

In proceeding eastward from the Rocky Mountains in the southern half of the continent, nothing deserving the name of a mountain-chain is met with, until we come to the Alleghanies or Apalachian chain, which running parallel to the Atlantic coast and near it, for a thousand miles from Georgia to the promontory of Gaspè in the Gulf of St. Lawrence, has a course of North 46° East, and consequently forms an angle of 72° with the axis of the Rocky Mountains.

Between the Apalachian chain and the Rocky Mountains lies the great valley of the Mississippi, having a width of 30° of longitude, in which space the Ozarh Hills, lying to the westward of the river, are the only eminences* having a mountainous character; but, were the general slope extended without excavation across the valley, their summits would not rise above its plane. The axis of these hills is parallel to that of the Alleghanies.

On the north side of the St. Lawrence basin, there is a formation of gneiss, granite, trap rocks, and conglomerates, flanked on both sides with Silurian deposits, which does not rise into a mountain-chain, but which, running nearly parallel to the line of great lakes, forms the brim of the basin and the watershed between it and Hudson's Straits and Bay and Lake Winipeg. From Lake Superior northwards the western boundary of this formation takes a course of North 30° West, and may be traced for 1600 geographical miles up to Coronation Gulf in the Arctic Sea; and it consequently inclines, though slightly, towards the axis of the Rocky Mountains, the intervening space narrowing considerably as we advance northwards.

This formation is hummocky rather than hilly, and its summits do not pass beyond the plane of the general eastern slope, or at least very rarely, although, when seen from the lake-basins, they occasionally assume an alpine character.

Of the forty degrees of latitude between the Gulf of Mexico and the Arctic Sea, the valley of the Mississippi occupies about one half, and the river has a descent from its source in Lake Itasca of 1500 feet†. Now the lake lies between 500 and 600 miles from the highly inclined base of the Rocky Mountains, which has an altitude of 2500 feet, and consequently one-third of the descent, were it equable, being accomplished at Lake Itasca, the height of the district in which the river rises would be 1600 feet. The sandy eminences (*hauteurs de terres*) near the lake, do not in fact rise perceptibly above this height.

Proceeding northwards from the sources of the Mississippi, we have a space between the 46th and 56th parallels, in which two great rivers flow transversely and cross the low intermediate granite and gneiss formation above-mentioned in their course to Hudson's Bay.

* The highlands in the northern counties of the State of New York are outliers of the Alleghanies similar to the projection towards Illinois at the south end of the chain, making, with the Ozarh Hills and Lake Superior rocks, fragments of a basin.

† More exactly 1490 feet.

Still farther north the Mackenzie drains seventeen degrees of latitude, and takes a course directly opposite to that of the Mississippi.

Now, referring to the map, and beginning with Lakes Michigan, Huron, and Superior, we can trace a chain of lakes that succeed each other in a line parallel to the Rocky Mountains, or more nearly perhaps to that of the strike of the granite and gneiss formation, viz. Rainy Lake, Lake of the Woods, Lake Winipeg, Deer Lake, Wollaston Lake, Athabasca Lake, Great Slave Lake, and Great Bear Lake, with Liverpool and Franklin Bays on the Arctic coast. All these (except the two bays) are excavated in Silurian strata with one end running in among the granite and gneiss rocks.

The Saskatchewan or Nelson River and the Churchill River run at right angles nearly to the line of lakes, crossing the granite and gneiss formation, and, if we examine the lake-basins individually, we shall find that often they take the same direction. For instance, if we take the most northern lake-basin, Great Bear Lake and Coronation Gulf, we find their axis to be about north-east.

The next in succession, Great Slave Lake, viewed in conjunction with the valley of the Great Fish River, is rather more nearly at right angles with the channel of the Mackenzie.

Athabasca Lake, with the large sheets of fresh water which discharge themselves into Chesterfield Inlet, have a similar direction.

More to the south, in the interval between the great N.N.W. and S.S.E. valleys of the Mackenzie and Mississippi, there is a change, the axes of the lakes running along the line of junction of the Silurian with the gneiss and granite rocks, while the rivers flow transversely and nearly parallel to the more northern lake-basins.

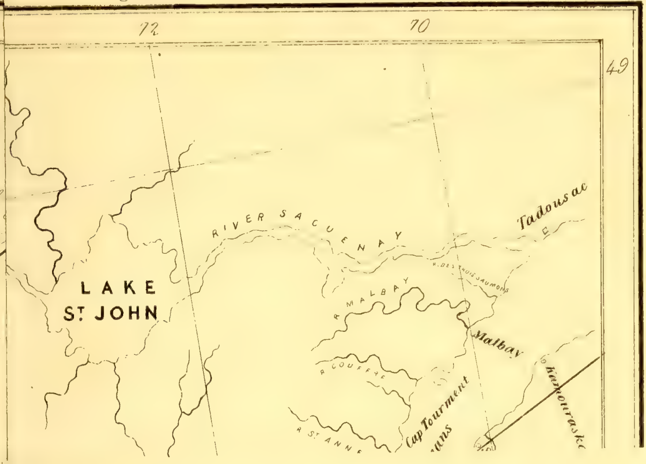
This parallelism is preserved by the River St. Lawrence, its lakes, and up to the west end of Lake Erie; but Lakes Huron, Michigan, and Superior, taken in the aggregate, make the northern bend parallel to the axis of the Rocky Mountains. The whole water-course of the St. Lawrence valley is in fact bent round the gneiss and granite formation above-noticed, and which sends out a projecting point between Lakes Huron and Ontario at the place of flexure. The southern brim of this basin, except at the New York highlands, is low, so that easy canal communications with the Mississippi valley have been established at various places. The basins of the lakes themselves and their southern borders are sunk in the strata of the Silurian or Carboniferous series.

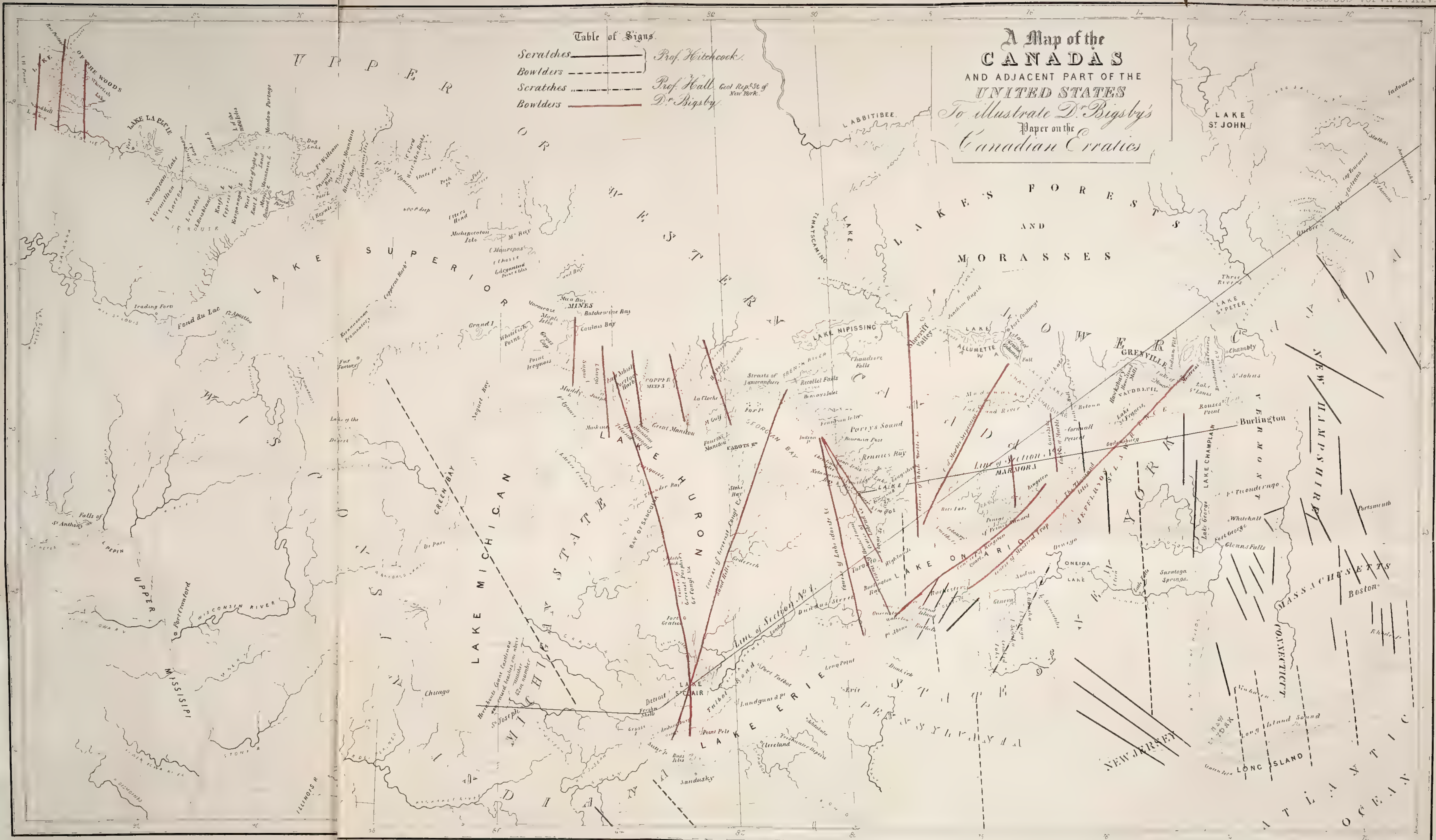
Perhaps the instances I have adduced will serve to show, that two great lines of fracture cross the continent, cutting each other at a large angle, approaching to a right angle, and that one of these lines preserves a parallelism to the gneiss, granite, trap, and conglomerate formation which lies between the Rocky Mountains and the Alleghanies, and in its course northward inclines a little to the former. In an account of my late journey through the country, now in the press, I shall offer further details, and enter more fully into the physical geography of the continent. In the mean time I shall be glad if this short notice elicits opinions from gentlemen more conversant with the science of geology than I am, and more able to judge of the bearing of such investigations.

Prof.

Prof.

Dr.


72
70
49
LAKE
ST. JOHN
RIVER SAGUENAY
Tadousac
R. DES TROIS SAUMONS
R. MALBAY
Malbay
R. GOUFFRE
R. ST. ANNE
Cap Tourment


A Map of the
CANADAS
AND ADJACENT PART OF THE
UNITED STATES
To illustrate Dr. Bigsby's
Paper on the
Canadian Erratics
Table of Signs.
Scratches
Bowlders
Prof. Hitchcock.
Scratches
Bowlders
Prof. Hall. Geol. Rep. St. of New York.
Dr. Bigsby.
UPPER OR WESTERN
LAKE SUPERIOR
LAKE OF THE WOODS
LAKE LA PLUIE
LAKE HURON
GEORGIAN BAY
LAKE MICHIGAN
GREEN BAY
LAKE ST. CLAIR
LAKE ERIE
LAKE ONTARIO
LAKE NIPISSING
LAKE TEMISCAMING
LABBITIBEE
LAKE ST. JOHN
LAKE ST. PETER
LAKES FORESTS AND MORASSES
LOWER CANADA
MICHIGAN STATE
WISCONSIN
INDIANA
NEW YORK
NEW JERSEY
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
LONG ISLAND
Long Island Sound
ATLANTIC OCEAN
MISSISIPI
WISCONSIN RIVER
Line of Section No. 1.
Line of Section No. 2.
MARMORA
GRENVILLE
Quebec
Three Rivers
Montreal
Burlington
Boston
Portsmouth
Chicago
Detroit
Sandusky
Cleveland
Kingston
Oswego
Rochester
Lake George
LAKE CHAMPLAIN
Saratoga Springs
Fond du Lac
Falls of St. Anthony
Chambly
Parry's Sound
Great Manitou
Thunder Bay
Goderich
Fort Gratiot
Point Pelé
Long Point
Dunkirk
Erie
Oneida Lake
Ogdensburg
Ticonderoga
Whitehall
Glenns Falls
Fort George
Tadousac

I shall merely add that the United States' geologists have shown, that, as we ascend the eastern slope of the continent, the superficial formations are more recent. We pass from the Silurian strata of Lake Ontario, to the Carboniferous series south of Lake Erie and in the peninsula of Lake Huron; and when we come to the prairie lands along the Missouri and Arkansas, Chalk fossils occur in abundance to nearly three thousand feet above the sea-level. Higher than this by some thousands of feet, at various localities along the base of the Rocky Mountain chain, Tertiary lignite formations occur, containing dicotyledonous leaves. It would appear that the country bordering on the Rocky Mountains was the latest deposited, and that that chain is the most recently elevated of the mountain ranges in the continent.

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3. *On the* Erratics *of* Canada. By John J. Bigsby, M.D., F.G.S.

The following notes on the Drift and other superficial detritus of the Great Canadian Lakes and of certain portions of South Hudson's Bay are laid before the Society with the intention of extending northward and westward the observations made on these points by Messrs. Hitchcock, Hall, Mather, and others in the northern parts of the United States.

An essay is not intended; the author merely offers his own personal notices, as written down on the spot. At the end of the Paper a few remarks will be offered.

It will not be necessary to describe these countries topographically, as the accompanying Map, Pl. XIV., will deliver us from anything so tedious.

I shall begin with the Lake of the Woods, and, proceeding eastwardly, successively note down my observations on Lakes Superior, Huron, Erie, and Lake Ontario.

Lake of the Woods.—The lake of the Woods lies 360 miles north of Lake Superior, and about 170 miles south of Lake Winnepeg, with which it communicates by the great river of that name. It is 400 miles round; and is severed into two unequal parts by a great promontory.

The rocks of the northern portion of the lake, called "Kaminitic," are wholly metamorphic. Granite and gneiss occupy its west shore and neighbouring crowds of islands, while syenite and greenstone prevail on its eastern and southern shores.

The larger and southern division has few islands, except on the north and east, where they consist of primitive rocks. The rest of the lake-shores, with little exception, are buried in fine sand, and hence its Indian name "The Lake of the Sand Hills." On the southern and western shores of Sand Hill Lake, where the sand has been removed, we have a few low mounds of gneiss and a large quantity of yellow limestone debris, either in small angular grits, or in sharp-edged blocks, some of which are several tons in weight; but in no instance could I be sure that they were fixed; nevertheless my belief is that these masses are in place; but split and shaken by thaws or moving ice. The main and isles of Lake Kaminitic being principally of rock and marsh, I did not notice on it any terraces. Coatings of soil, clay, and sand exist, but they are scanty. It was not in my power to examine them.

The shores and isles are loaded, more or less, with masses of primitive rocks from 1 to 20 feet long, and in various states of attrition; some as if freshly detached, others much rounded, although of hard materials. These boulders are of grey gneiss, various granites, hornblende-rock, mica-slates, greenstone, and greenstone-porphyries, with red and white felspar, and almost every variety of primitive rock; but a careful search could not detect a single fragment derived from the southern or Sand Hill portion of the lake.

These primitive boulders mostly come from the river Winnepeg, &c., on the north*. In a few instances I traced them to their parent rock within the lake.

They all lie naked, and stranded, as it were, without any regularity in heaps, here and there, on isle and mainland. Some of the very largest, weighing, by guess, a hundred tons each, were found on the points of greatest elevation.

As to the southern part of the lake, its northern and north-east water-margins are defended with innumerable blocks (as in Lake Kaminitic); ranging from 1 to 20 feet in length, and sometimes 10 feet high; seldom rounded; some in the water, and others on the beach, more or less buried in gravel and sand, both which abound here far more than in Lake Kaminitic.

There is a longish strait near to, and north of, Turtle Portage, whose north-west side is faced (plastered, as it were) with grey clayey earth and boulders to the top (100 feet); but on its south-east side there are no boulders, only a little clay.

The same thing occurs in the first narrow east of this Portage; and again in a strait six miles to the south-east; the boulders being in extraordinary quantities,—granite, gneiss, and greenstone-porphyries.

A solitary mound of gneiss, six miles from shore, N.W. of the river La Pluie, carries a sort of rocking-stone almost as large as itself, but not of the same kind of gneiss. The southern and western shores are skirted by low hillocks of loose sand, with rounded and angular blocks in front, and lagoons in the rear.

This is particularly the case with the S.W. shores, where the waters are shallow, and landing made difficult by the quantity of boulders lying on and about the beaches, while lagoons and lakes, choked with reeds, extend westward from 80 to 100 miles,—to the Buffalo Plains in fact. The sand-banks here contain no erratic blocks, except at one place to the east of Reed River. They do not appear to be stratified.

These south and west shores had but little mixed gravel or pebbles, but almost everywhere there lies dry on the beach straw-coloured, clouded, red and white, chertzy limestone in fragments, from a state of mere dust to angular masses weighing a ton each. This limestone is full of organic remains characteristic of the upper portion of the

* Keating. Long's Travels to the Sources of the St. Peter, vol. ii. pp. 103, 112.

Silurian System, according to Mr. Logan, who had the kindness to examine some of my specimens.

On the west mainland, a little north of Monument Bay, there is an island, which is almost connected to the main by an immense depôt of primitive boulders, principally foreign to the lakes; while its eastern end is in deep water.

The points to be noticed in the Lake of the Woods are—the abundance and universality of primitive travelled blocks,—their northern origin,—the total absence of calcareous erratics on the north,—and the large sand-beds in the southern part of the lake.

There may be striæ and scorings, but they did not attract my attention here as they did in the Canadas.

River and Lake La Pluie.—We now proceed to the beautiful river La Pluie. This river flows westerly for eighty-five miles out of Lake La Pluie, and pours into the Lake of the Woods near long. 95° W.

It passes through a level or rather undulating country, with banks varying from 5 to 50 feet in height, with terraces here and there, although rarely: these, however, the luxuriant forests only permit to be seen for short distances.

Throughout the whole length of the river La Pluie, its banks expose a grey clayey and loamy soil, full of small angular fragments of the yellow limestone of the Lake of the Woods, intermixed occasionally with round lumps of gneiss, from the size of the fist to that of the head. I saw no marks of stratification, nor any marine or freshwater shells.

The limestone was sometimes, as just below Fort La Pluie, so plentiful and fine as to form a conglomerate rock with a calcareous paste and nodules of primitive rocks; while close to and below the river Boudet the limestone masses have concreted into a hard breccia, without the primitive nodules. There are not many primitive boulders lying exposed on the river La Pluie; but they are in great numbers at the Long Sault and Manitou Rapids,—obstructed points in the river, where sand, gravel, drift-wood, and large boulders of trap, &c. have greatly accumulated. Along the Manitou Rapids and elsewhere we see a good deal of pure clay in the banks.

It may be safely concluded from reasons not necessary to be mentioned here, that the Sandhill portion of the Lake of the Woods and a considerable region around the river La Pluie form one great limestone basin. By far the larger part of the superincumbent detritus is native, while the foreign comes from the north,—not from the south, with whose rocks I am tolerably well acquainted.

Rainy Lake, 1160 feet above the level of the sea, 300 miles round, but of a most irregular shape, next succeeds on our route southwards towards Lake Superior.

For a few miles round the mouth of the river La Pluie we have the yellow calcareous debris, before spoken of, in large quantities,—one mass I saw weighed more than a ton; but on entering further into the lake we see no more of it.

I observed no terraces in Lake La Pluie; the general level being low, except on the N.E., and its shores usually marshes or sunken mounds of rock.

But quartzy sand, with and without primitive pebbles and banks of gravel, or beaches, were not entirely wanting; the sand is coarse and gritty, and reddish yellow, as in most of the small lakes between this and Lake Superior.

Boulders are general and very large, some weighing tons, moderately rounded, and often angular. Those of the Lake of the Woods are sometimes, but not often, seen here; but these mostly belong to the lake itself, and consist of grey gneiss (with staurotide), white granite, trap, greenstone-slate, greenstone-conglomerate (the nodules being primitive), very much mica-slate, large-grained syenite, and hornblende-rock; most of these rocks occur in the fixed state in the lake, and especially at the north-east end.

These deposits hang upon the lake-shores without any display of stratification, and seem to belong to the present system of things.

Lake Lacroix.—I merely crossed over this lake—the next large body of water. It is full of islands, and did not exhibit on its surface much detritus; but it is fertile in parts. Most of the larger erratics are angular and often many feet long and broad. They are of the lake and may be called home-erratics;—consisting of slabs of mica-slate, greenstone-slate, and various granitoids.

From Lake Lacroix to Lake Superior, a distance of 177 miles, my opportunities for observation were very scanty. I was hurried along narrow watercourses, marshes of wild rice, through shallow lakes, or extensive sheets of water bounded by basalt slopes and precipices. I noticed, however, that almost universally all the obstructions to the water-way, such as narrows, shallows, and cascades, were encumbered with boulders and gravel.

Lakes La Croche and Keseganaga.—In Lake La Croche there are banks of brown sand and clay, with large primitive blocks, sometimes so white and large as to look like a group of white Canadian houses.

Seven miles from the Upper Portage of this lake, there is a still-water narrow, only thirteen yards wide, so choked up with angular boulders, probably native, that our canoe could barely work through them. Of this interval, therefore, I shall only say a few words. Throughout Lake Keseganaga, a large body of water (long. 91°), as far as I saw, the soil is two-thirds composed of very small primitive pebbles, intermixed with pale brown clay, sand, and angular grit.

At and about the Fall of Small Pine Rocks, very many large blocks of impure hornblende, quite angular, are found lying on granite.

On the top of the trappose precipice overlooking Outard Lake, 1200 feet above the level of the sea, I found a large block of gneiss, but little rolled.

North of the Grand Portage I never met with an erratic from Lake Superior. On the summit level of that Portage, however, are two immense blocks of amygdaloid, similar to that of the Pays Plat of Lake Superior.

Lake Superior. Loose Detritus of North Shore.—We now pass on to remark in some detail on the *loose* materials of the north shore of Lake Superior,—a body of water occupying a crescent-shaped trough, 1700 miles round, 420 miles long, by 163 miles in its greatest breadth. Prof. Agassiz is of opinion that it owes much of its present size and form to successive eruptions of basalt. Its surface is 623 feet above the sea*. By far the greater part of its debris is strictly local; a second part belongs to a distant part of the lake, ranging from two to eighty miles; while a third, the distant or foreign erratics, comes from the granitoid, trappose, and Silurian regions of the north; much of it from the first 400 miles north of Lake Superior.

These large, somewhat angular, foreign boulders do not often meet the eye, because much of the north shore of this lake is rock-bound, its beaches narrow, and its waters deepen rapidly, while the adjacent country is steep, and its confined valleys are loaded with moss and other vegetation.

The lip or margin of the south shore, on the contrary, is comparatively low, and the region around rather level, some of its greatest elevations at the water-side being high sand-hills, formed by the prevailing winds from the friable sandstone of the south-east of the lake.

The debris which can be traced home on the north shore of Lake Superior is in great quantity, and is either large (blocks from 1 inch to 15 feet long) and lying naked more or less profusely on the beaches, or it is sand and grit, forming horizontal deposits of great thickness, which border the lake and its tributary streams in the shape of terraces, and which enwrap the neighbouring hills in level plains, sometimes small, at others extending many miles in every direction.

We will first speak of the detritus at the water's edge;—beginning at the Grand Portage, the most westerly point of Lake Superior with which I am acquainted, and 442 miles from the Straits of St. Mary leading into Lake Huron.

At the Grand Portage the beach is strewn with various traps, amygdaloids, red and brown argillaceous porphyries, masses of baked clay, or coarse jasper, red and white sandstone (the last traceable to a locality six miles distant to the N.E.), clay-slate with veins of quartz and amethyst, chert, and some limestone. Fixed rocks exactly similar to these are found at Nipigon, &c., on the E.N.E.; but the detritus may possibly have come from Isle Royale. It may be here remarked, that these boulders have travelled from the N.E., contrary to the prevailing winds and to the existing lake-current. The iron-bound coast from the Grand Portage, for sixty miles eastwards, to near the Mammelles, for the most part merely exhibits sharp-edged fragments of the trappose sub-rock.

The beaches of the numerous isles of the Mammelles are loaded with large traps, indurated red sandstone, and a pale limestone (Silurian) rolled into balls of from 3 to 8 inches in diameter. All this detritus, excepting the limestone, is from the vicinity,—from the north or north-east; limestone is not known to occur *in situ* on the north shore, except at Thunder Head.

* The true height of Lake Superior is 600 feet above the sea, according to Mr. Logan.

In the Pays Plat, my notes seldom speak of foreign erratics. Most of the loose rocks are from localities in a N.E. direction near at hand, or not more than fifty miles from home. They are peculiar and easily recognised; consisting of various porphyries, pudding-stone with nodules of primitive rocks, dense porcelain-like sandstone, and Silurian limestone (both associated with amygdaloid).

The Pays Plat contains several bare flat terraces, a mile or more in diameter, with some very distant erratics and drifted trees scattered upon them.

Where the sub-rock is a dark amygdaloid, the beaches are rusty black, with a few stray blocks upon them; where it consists of porphyry or sandstone, we have a brighter or darker red,—the line of division being abrupt and striking, far more so than would be, if there were tides or currents in this lake. The large debris at the water's edge of the mainland opposite the Slate Islands, near the Black River, for some miles east and west, is composed of traps, red granite, syenite, and quartz-rock, with finely granular limestone, very siliceous, white, and fossiliferous. If this limestone be not from the north, where there is plenty, it may form reefs in the depths of the lake. The beaches of the syenitic district north of Peek River are largely strewn with blocks of hypersthene, from the vicinity.

For fifteen or twenty miles on each side of the Otter's Head (a well-marked spot), by far the largest part of the detritus on or near the beach is native,—if we except the limestone above referred to. It is almost wholly derived from the imperfect grey granite and the numerous trap-dykes of this vicinity.

From Otter's Head along and across the great Bay of Michipicoton to Capes Maurepas, Choyyé, and Gargantua, the shores are commonly, but not always, too steep to allow of resting-places for wandering rock-masses.

Such as I noticed had not travelled far. South of Gargantua Point, an amygdaloidal district, we fall in with the various coloured sandstones of the region in some profusion, with a few amygdaloids, traps, &c., as before.

One mile S.E. of Gravel River I landed and found the larger debris to be principally gneiss and greenstone, veined with granite or felspar (found in the vicinity),—the amygdaloids and porphyries having disappeared, the latter indeed for the last 100 or more miles.

In the great bay of Huggewong, the loose masses on the beach are principally the native white, slightly laminated, granite.

In this neighbourhood I met with a singular freak of nature; viz. a handsome fir-tree growing on the flat upper surface of a very large block of conglomerate (from Marmoaze on the north), itself standing upon four boulders of granite.

The bay next to Batchewine is lined with debris of white horizontal sandstone (Potsdam); its ledges forming the projecting points of the indents.

Batchewine and Goulais Bays being close to the throat or narrows leading to the river St. Mary, a considerable change takes place in the detritus on their beaches; which are plentifully strewn with large boulders, one-half of which are trap, the remainder being brown and greenish amygdaloids, brown and green porphyries, granite, gneiss, jasper-pudding-stone, greenstone-conglomerate, hornblende-rock, and sandstone,—all directly traceable to the north and east*.

St. Mary's River, on its left side, is faced with coarse ferruginous sand-banks (derived from the sub-rock), with trap and sandstone blocks on Pine Point.

The Rapids or Falls of St. Mary are surrounded with great collections of travelled rocks, both on the Canadian and the American sides of the river. The chief are gneiss, greenstone, granite, jasper-pudding-stone, mica-slate, greenstone, porphyry, conglomerate, and angular masses of the sub-rock (Potsdam sandstone). I saw one piece of the La Cloche crystalline quartz-rock. The small bays and coves and the river itself, above the Falls, are crowded with these erratics.

Bedded Detritus of the N. Shore.—Although it be true that much of this north border presents only precipices, rugged steeps, and dome-shaped hills, varying in elevation from 100 to 1400 feet above the lake, swept bare by arctic winds, or washed by melting snow, nevertheless in their intervals we find arenaceous and argillaceous deposits in large areas for 100 miles inland (according to our present knowledge), and bearing thin forests of pine, birch, and poplar.

These deposits also face the lake in the shape of bare earth-banks and terraces. They are all the product of the lake when standing at higher levels; and are local drift, deposited most commonly in times of disturbance, but not always, as we find them stratified in Michipicoton, Huggewong, and Batchewine Bays. Most of the materials are from fixed rocks close at hand.

The first set of ledges I saw in travelling eastwards was in the Mammelles Isles, consisting principally of porphyry shingle. They are low, not exceeding twenty feet altogether, although from one to six in number passing inland for one-third to two-thirds of a mile, and are dotted with trap-boulders.

These are formed by the tempests of the present day. Not so, however, the great beds about the mouth of the picturesque Black River, opposite the Slate Islands. At the lake-side these earth-banks are 330 feet high (Logan), sloping downwards in the rear, and consist of very small angular and round bits of granite, trap, and quartz, imbedded in a coarse dark brown sand, pressed hard together. The granite is derived from the disintegration of the hills of that rock hard by, and the other rocks are in place nigh at hand.

This deposit forms a plain, naked save for a few wretched pines and, here and there, a block of brown quartz-rock or gneiss, derived from the north. It extends five or six miles into the interior to a line of high bare hills. Along the lake-side it extends east and west as far as the eye can see from a considerable elevation; and it is intersected by the Black River, which has three terraces on each bank. In the middle of the plain I found a pair of deer's antlers lying on the ground. Near the lake, one mile and a half *west* from the

* Mr. Logan has seen specimens of jasper-pudding-stone found *in situ* in Goulais Bay.

mouth of the Black River, the gritty deposit overlooks the water in two lofty stairs or embankments; but to the *east* of the river the plain lowers in a succession of banks, six in number, except in places where from occasional coalescence they become fewer.

Close to the river's mouth, on the east, all the stairs or ledges have been swept away, and are lost in one great concave of 1300–1500 yards' chord, facing both river and lake. This feature arrests the traveller's eye instantly, and is well represented in Prof. Agassiz's late work on Lake Superior*.

I saw no means of ascertaining any differences as to the time and mode of deposition. There may be stratification, but I saw none; and neither Prof. Agassiz nor Mr. Logan mentions any. I therefore take these deposits to belong to one long epoch, from their materials being always in the same splintered or pounded state; and from their being in such large quantity. A few miles east of this (thirty-four miles W.N.W. from Peek River), we find a bay whose shore rises 20 feet by four ledges of rounded pebbles. These are surmounted by two banks of sand and gravel; the first rising at an angle of 50° to the height of 25 feet; and the second to the height of 40 feet,—with a terrace on the top, therefore, of 85 feet elevation.

The shores fourteen miles east of the Otter's Head, and for twenty or thirty miles hereabout, present many high banks of this sort;—the materials are native.

At the mouth of the Michipicoton River are extensive ranges of sand-hills, of which one near the fort is 60 feet high, and is composed of stratified sand and gravel†.

At Cape Choyyé Prof. Agassiz found a beach with five terraces; the lowest one falling steeply into the water some 20 feet, showing that it alone can be connected with the present level of the lake, and the rest must belong to former epochs‡.

Twelve miles south of Gargantua commence a series of deep and extensive deposits of white siliceous or granitic sand, reaching to the northern angle of Huggewong Bay (seventeen miles). White granite prevails here.

The bottom of this bay is faced with sand-banks, which retire in successive terraces a mile or two inland, and are lost to sight from the lake.

The outer half of its south shore presents the same appearances; but here the sand is intermingled with large and small boulders of the rock of the district (fine-grained white granite),—not always in confusion, but often in horizontal layers. These banks, 10–30 feet high, run out of sight behind the adjacent hills.

Of the interval between Montreal River (where we have now arrived) and St. Mary's River, it will suffice to say, that wherever a cove or bay occurs, while the points are armed with fixed rocks, the inner shores are gravel- or sand-banks, from 5 to 30 feet high; the latter always much mixed with boulders, and passing into the rear

* Lake Superior, its Physical Character, Vegetation, and Animals, by Louis Agassiz; with a Narrative of the Tour, by J. Elliot Cabot, &c. 8vo. Boston, 1850.

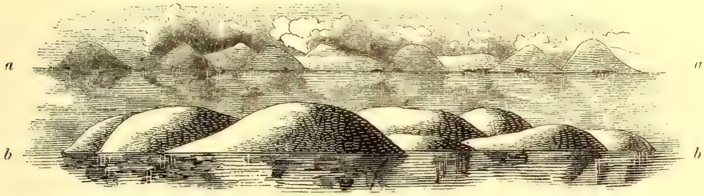
† Agassiz, *loc. cit.* p. 60. ‡ *Loc. cit.* p. 57.

to abut upon lofty hills. The boulders are arranged either confusedly, horizontally, or in short interrupted lines at different angles with the horizon.

Before we leave Lake Superior, we may advert to the form of the trappose islands of the north shore in the neighbourhood of the Peek River. They are in very low, oblong ridges, rounded like woolsacks or the backs of sheep (*moutonnée*), with very narrow intervals between them growing bilberries. The surface of these ridges or mounds is often glazed to the depth of half an inch.

Fig. 1 represents one of these islands. It is 30 feet high.

Fig. 1.—*One of the low bare Greenstone Islands about the Peek, Lake Superior.*



a. Mainland, consisting of Granite and Syenite, near the Greenstone Islands (6 miles off).
b. Island of Greenstone, rounded and *moutonnée.*

Lake Huron.—The rocks of Lake Huron, its contour, and its depth being different from those of Lake Superior, we necessarily find the nature and quantity of its detritus also to be extremely different.

An idea of its shape can be best obtained by a glance at the Map, Pl. XIV.

It is 1000 miles round; and about the middle is sometimes 1000 feet deep, being often shallow, however, along its northern division. It is 594 feet* above the Atlantic; and is all but bridged over lengthwise by a chain of large islands.

The north shore of Lake Huron is mostly low and marshy; seldom showing cliffs overlooking deep waters, as in Lake Superior; and its hills (once or twice 700 feet high) approach the lake at a small angle in successive ranges or lines; and thus leave low intervals between them, in which rivers may flow and detritus accumulate.

Its eastern shore from Penetanguishene to Notawasaga Bay, having Lake Simcoe ($125\frac{1}{2}$ feet higher) in the rear on the east, rises in steps to no great height, perhaps 300 feet, based on limestone; these are much covered by sand and erratics.

From Notawasaga Bay to Cabot's Head the coast displays, first, ranges of clay or sand-hills, and then a series of limestone cliffs.

From Cabot's Head, or near it, to the river St. Clair, a distance of 140 miles, the south-eastern shore is laid out chiefly in tall cliffs of sand and clay; but of which I know nothing, having never been nearer than two miles from them.

* The correct height of Lake Huron above the sea is 578 feet, according to Mr. Logan.

The south side of Lake Huron, in the State of Michigan, abounds in sand-banks and low ledges of horizontal limestone; the interior being low and undulating, with ridges of sand and loamy hollows, interspersed with small lakes: the region is very fertile in parts.

The detritus of Lake Huron, like that of Lake Superior, is accumulated principally on its eastern and southern coasts. But here the erratic boulders are everywhere seen; and they abound in immense numbers on the north shore; on this latter portion of the lake's margin I did not see a single ancient terrace, which nevertheless may exist. The boulders occupy the hill-sides, beaches, and shallows of main and island; they are little worn, of the usual large size, and lie irregularly on the surface. Their numbers are great on the most western Manitouline, Drummond Isle, and considerable on the Little Manitou.

Blockhouse Hill, once the west end of Drummond Isle, is the level summit of a slope 400 yards inland, behind Collier's Harbour Village. Eighty or a hundred feet above the lake, just where the slope rises into a perpendicular ledge of limestone, it is strewn with large primitive boulders, but little rolled; and the village street is rendered almost impassable by blocks from 4 to 10 feet long, although many have been removed. They are principally local, but among them we see much syenite, trap, quartz-rock, and some jasper-pudding-stone;—all from the N. and N.N.E.

The higher grounds of the contiguous Manitouline, about the middle of its northern side, are rugged with these same primitive erratics.

On the sides of the steep slope forming the south point of St. Joseph Island, there are the remains of successive belts of water-worn erratics of large size, one above another, with a few yards' interval between each. Besides these, many blocks are scattered about in the vicinity. The same occurs eight miles to the east, in Worsley Bay, near the south-east point of the island.

Between St. Joseph and the False Detour, and perhaps four miles from the latter, is an island called in the map of the American Boundary Commission, High Cliff Island, one of a group. On the summit of this cliff (which is 100 feet high, and consists of fine granular sandstone), Col. Delafield informs me there is a range of water-worn stones, mostly limestones, traps, and quartz-rock, regularly strewn, as on a beach, for 200 feet in length.

These instances of the remains of ancient deposits might be greatly multiplied, as they are very usual in this lake, when the vegetation permits them to be seen. The debris crowning the heights, or hanging on the slopes, of this part of Lake Huron, is almost altogether gneiss, syenite, and trap; derived not from the S., but from the N. and N.N.E.; for no such rocks exist in a southerly direction for 2000 miles, if we except the Alleghanies, which are themselves very remote. I cannot distinguish this debris from the fixed rocks on the north of Lake Huron, and towards and in Lake Nipissing.

The high cliffs of the main in the narrows of Pelletau are of coarse greenstone-slate and greenstone-conglomerate; but the surface is so shivered and disintegrated by alternate thaw and frost, that it is not easy without tools to get at the rock below.

This state of things is somewhat unusual in Lake Huron, for the primitive rocks are ordinarily sound, often highly polished and rounded like woolsacks.

In these narrows, which are about a mile wide, we see that each shore is lined exclusively with its own debris.

The loose masses on the north side of Lake Huron belong in the greater proportion to the immediate vicinity ; but these vary greatly as we pass from Point Thessalon to Penetanguishene, about 280 miles.

Between the rivers Thessalon and Missassaga, and especially thirteen miles east of the former, the beach is so encumbered with erratic boulders as to impede landing. They are granites, traps, and gneiss, with a quantity of the jasper-pudding-stone, so much admired by all who have seen it*. Black trap seemed to form the most abundant boulder. I saw no loose limestone on the main shores west of the river Missassaga. It was here that I was puzzled by the almost constant scorings and striæ (unconnected with the stratification), by the polished and glazed surfaces, and the woolpack forms of the rocks around,—appearances precisely similar to what I afterwards saw in Switzerland and in North Wales, but which in 1824 I was quite unable to interpret.

Eleven miles east of this river the main shore and its beach are remarkably infested with large blocks. On a syenite island in the offing here, one of a nameless group, quartz-rock, rendered slaty by the presence of mica, is introduced largely among the traps, granites, and jasper-pudding-stones, and so continues through the Le Serpent district on the east. The micaceous rock comes from the hills of the mainland at La Cloche, where I have seen it.

As we approach the La Cloche district, and pass through its groups of isles and winding sheets of water, as far as Collin's Inlet, square masses (5–20 lbs. weight) of sparkling, fine-grained quartz, line almost every shore nearly to the exclusion of all other rocks, except now and then slabs of Trenton limestone, loose or in place, full of fossils. In Collin's Inlet these quartz-rocks are rolled; elsewhere they do not present that appearance in nearly so great a degree.

The quartz-rock prevails in a fixed state for many miles around, and is traversed by dykes of trap. One very large black block of trap was shown me on the mainland as having given the district its name, from its ringing loudly on being struck.

Proceeding eastwards, on and around the Fox Islands, opposite Collin's Inlet, thirteen miles west of the French River, the boulders of jasper-pudding-stone re-occur, with much greenstone, porphyry,

* I saw here a cubic block of 4 feet every way. It has been described by Logan and others. I saw this description of debris *in situ* on the adjacent shore, as well as on the Isle of Encampment Doux (not D'Ours) at the East Nibish Rapid, where the white crystalline quartz-rock is striped by bands (1–5 feet broad) of red, brown, and green jasper nodules. Mr. Logan also found it in great mass in a small lake three miles from Lake Huron, near Portlock Harbour, and on Thessalon Lake, some miles to the east.

and conglomerate, various traps, a large lump of silvery mica, the La Cloche quartz-rock, and gneiss with garnets from the French River. The last is from the north-east; all the rest are from localities in a N.W. direction ten to eighty miles distant.

The French River, on its way from Lake Nipissing to Lake Huron, passes through a desolate country. There is, however, some miles distant easterly a very large and high table-land, covered with fertile deposits. While descending this river with great rapidity, I was chiefly struck with the effect of cold upon its shores. The rocks (various forms of gneiss, &c.) were usually split up into large sharp-edged, oblong masses, often piled by freshets one upon another. At one place they almost dammed up the channel down which we were passing. Among the innumerable islets off Parry's Sound, still further east, I noticed two great piles of sharp-edged slabs of gneiss, having all the appearance of having been brought there and thrown down pell-mell; but they are, most probably, the work of the ice during spring-freshets.

On the beaches (west of the Key on the north shore of Lake Huron), eleven miles east of the French River, we saw no more jasper-pudding-stone, and little quartz-rock, but various forms of greenstone, granite, and gneiss, and two blocks of impure labradorite; one of the blocks weighing 250–300 lbs.

On the rugged north shore near Henvey's Inlet, about twenty-five miles east of the French River, the beach is strewn with black, brown, red, and white slates (either argillaceous or of greenstone), various porphyries, granite, gneiss, and labradorite; the slates and porphyries forming two-thirds of the whole.

There is not, as far as I could ascertain with care, a vestige of limestone, loose or fixed, on this part of the north shore; although it is *in situ* on Limestone Island, ten miles south of Franklin Inlet; and Cabot's Head, which is composed of limestone, is fifty miles to the west.

The labradorite occurs in a fixed state on a group of pine-covered islets, thirty miles N.N.W. of the Giant's Tomb, a little way within the lake, opposite Parry's Island*.

From near Henvey's Inlet, and still more characteristically from near Parry's Sound, the labradorite boulders overspread the north shore and its isles, in company with gneiss, trap, granite, and the quartzy hornblende that we find imbedded in gneiss on the N.E. coast of Lake Huron.

* This group of islets is five miles long. The rock is unstratified labrador-felspar, forming whole islands. It generally contains interrupted lines of plates of black mica, and occasionally large imbedded masses of hornblende. Its outer surface is apt to weather soft and powdery white; but it is as often sound and of a shining green colour, with a few iridescent (blue and red) spots, which when the rock is wetted, overspread the whole surface; as was the case on the rainy day when I passed by. This rock occurs in great quantity in Essex and St. Lawrence Counties, in the State of New York, and was first described by Dr. Emmons in his survey of the Second Geological District of that State. Mr. Hunt, in his Report for 1848 on the Geology of the Canadas, notices the existence of a boulder of this highly ornamental rock in Bathurst, near the Rideau Canal, to the N.E. of Lake Ontario.

The labradorite is often met with on the eastern coast of this lake, as well as in Lake Simcoe; in a southerly direction from whence it is noticed in decreasing quantities for thirty miles, as far as Lake Ontario; and even at the outlet of this latter lake, nearly 300 miles to the south-east, a few blocks of this well-marked rock may be seen; to this last-named locality, however, it may come from Bathurst on the N.E.

The water-margin of the cairn-like island called the Giant's Tomb, four and a half miles from the Christian Isles, struck me as being remarkable. Its north shore is scraped clean to the rocks by the waves, which wash the very roots of the bushes; the east beach has a thick coating of fine sand, while the south and west sides of the island are covered with vast numbers of transported blocks only, which are of great size. They consist of labradorite, syenite, gneiss, hornblende-rock, and flat pieces of fossiliferous limestone.

If we cross northwards from the Giant's Tomb to some islets, scarcely half a mile distant, we entirely lose the limestone.

The Military Station of Penetanguishene, hard by in Gloucester Bay, takes its name from the high sand-hills, with blocks of granite and trap, with which it is surrounded.

I am but little acquainted with the south-east coast of Lake Huron; which is, however, extremely well worth examination.

Of the great curvature, called Notawasaga Bay, sixty miles round, I know only the north wing, from the Christian Isles to the river Notawasaga, not quite one-half.

The adjacent land here, which is well-timbered, rises rapidly to the height of 300 feet or more, presenting two or three distinct ledges of horizontal rock, faced with a thin covering of sandy soil. In various places between Penetanguishene and Lake Simcoe, there are mounds of sand; some of which have been recently opened, and each has been found to be the receptacle of hundreds of Indian skeletons, with many kettles, wampum, &c.,—perhaps the result of savage warfare 200-300 years ago*.

Whilst the ordinary line of coast on the north side of this bay exhibits only low round sand-hills, and not many primitive boulders, these latter beset the little points and angles in great numbers; the boulders are sometimes of several tons weight, and similar in kind to those met with on the Isle of the Giant's Tomb,—from the N. and N.W.

The river Notawasaga, in its course from the east, affords many beautiful sections of the country for twenty miles from its mouth.

In the right bank of this river, about twelve miles from its mouth, and three miles below the commencement of its rapids, there are two horizontal layers (each 4 or 6 inches thick) of large shells, closely packed, of the genus *Unio*; this genus is common in Lake Huron at the present day, but the recent specimens have not such thick shells as the fossil species. The beds are one or two feet apart, and are buried under a sand-hill, which is from 80 to 150 feet high, and through which the river forces its way. The shells are in various

* Assistant-Surgeon Bawtree, in Jamieson's Journal, vol. xliv. p. 87.

states of preservation,—from a nearly sound state to a condition resembling calcination. They are most commonly composed of loosely cohering layers of soft calcareous matter, of a bright pearly lustre; and are therefore extremely fragile. Both valves are often in contact, and are filled with smaller shells and sand; but the majority are broken into small fragments, or have even fallen into a white powder. The small shells just spoken of are *Planorbes, Physæ, Lymnææ, Melaniæ, Paludinæ*, &c., and are particularly abundant in a living state in the river Notawasaga; and thousands, like those buried in the sand, are lying dead on the strand about the mouth of the river.

While the *Uniones* occur by themselves, squeezed together *en masse*, a great number of the others are scattered about in the sandy layers around.

These two remarkable seams of shells are very distinct for three miles downwards, and are from time to time visible nearly to Lake Huron. They extend most probably a considerable distance from the river laterally. The lofty bank in which the shells occur is minutely stratified. Above, it is composed of coarse brown sand, with very thin sprinklings of gravel, and in one spot, at about mid-height, three contiguous layers of small pebbles occur;—below, it consists of very white and fine sand, which rests upon white clay, mixed with pebbles, similar to those in the sand. This clay, or marl-clay, forms the river-bottom; it has a fine texture, and breaks conchoidally, or crumbles. In one place it is 20 feet thick above the level of the river.

Of the very extensive south coast of Lake Huron I only know what may be gathered from a coasting-voyage, and from landing at two or three spots, as at Presqu'isle and in Thunder Bay, where I found erratics of trap and jasper-pudding-stone, and native slabs of limestone,—derived from the N.

The main shore is everywhere low; the beaches are sandy, but the points are either faced with broken ledges of limestone, or with numerous erratics.

River St. Clair, Lake St. Clair, and River Detroit.—I now quit Lake Huron for the River St. Clair; of which, for want of fuller notes, I have only to say, that its larger detritus is from the north shores of Lake Huron.

Lake St. Clair, being in a marshy country, shows very little detritus, and this on its south shore, where the few small stones that are to be seen have been derived from Lake Huron. I particularly remarked the handsome greenstone-porphyry of its north shore.

In the river Detroit, the gneiss, granite, and trap of Lake Huron are plentiful, but not large. The clay of the banks of this river contains freshwater shells;—a fact of considerable importance*.

Lake Erie and River Niagara.—Lake Erie is situated in the lowest depression of the great level south of Lake Huron and west of Lake Ontario.

As this vast tract of low undulating ground is overspread with great sheets of blue and red clays, having sands above them, so we

* Mather, Silliman's Journal, vol. xlvii. p. 261.

find the north shore of this lake (and much of the south shore) bounded almost wholly by similar deposits. These are found from the river Detroit to Long Point (285 miles) in banks and scarps, usually of considerable elevation.

Sixteen miles east of the river Detroit, the scarps are at least 100 feet high. The under portions are greyish blue clay *, both in horizontal interrupted flakes, and amorphous; while the upper parts consist of sand and primitive pebbles, capped with a light-brown loam, which is very fertile. At the western portion of these cliffs (some miles long), the pebbles become boulders; but at the east end, both disappear, and we have only fine sand †.

On the beach in front are many erratics, derived from the north of Lake Huron, some weighing several pounds,—greenstone-conglomerate, porphyry, traps, &c., angular and rolled limestone, together with large quantities of red sand, which the microscope shows to be fragments of garnets.

The beaches on the north-east shore of Lake Erie, west of Grand or Ouse River (240–260 miles east of the last-mentioned locality), are strewn with myriads of dead freshwater shells, accumulated to the depth of some inches. The detritus here (eight miles west of Grand River) does not come from Lake Huron. The preponderating debris is the Medina Sandstone of Niagara. I saw one slab weighing 100 lbs., and many smaller and rather angular slabs. They are seen all the way (twenty-four miles) to the Niagara River, with occasional masses of labradorite (Bathurst, &c.) and very large blocks of white crystalline limestone of the N.E. border of Lake Ontario, or of the Ottawa River.

About the mouth of Grand River, as well as at Long Point, high dunes of loose pure sand occur. These are sometimes very ferruginous, and, with occasional intervals, occupied by cliffs of red clay (one of which between one and two miles long occurs three miles east of Grand River), extend to the river Niagara. The red clay contains angular fragments of the local limestone, and rolled primitive blocks, marble, labradorite, and gneiss, as before mentioned.

There may be ancient terraces belonging to Lake Erie on the north, but I have not seen or heard of any.

In speaking of the river Niagara, I shall only add a fact or two to the curious details respecting its post-pliocene condition already given us by Sir Charles Lyell and by Mr. Hall, the State Geologist of New York.

The river-banks of impure clay about the Falls, up to Chippewa, and so on towards Lake Erie (those of Goat Island), are full of small fragments of Niagara limestone, both angular and rounded; a fact observed all over the valley of the St. Lawrence. Everywhere we

* This blue clay also covers much of the opposite south coast.

† Although (after much trouble taken) I could find no shells here, Mr. Whittlesey lately discovered freshwater shells, *Planorbes* and a *Helicina*, beneath the nearest ridge on the *south* shore, near Cleaveland; the ridge is composed of sand or fine gravel derived from the subjacent rocks (Sillim. Journ., New Series, vol. x. p. 31).

have comminuted masses of the sub-rock, equably mixed with erratic blocks,—forming sand, clay, or gravel.

In the chasm near the Falls I only saw one boulder; this was gneiss with garnets,—from the north,—precisely similar to what I saw on Lake Nipissing. The fields for a mile or more (most probably much further) in the rear of the Canada side of this river present numerous erratic blocks,—dropped at hazard, as it were. Many of them are gneiss and syenite, but a large proportion are a peculiar blue milky quartz-rock, which is found *in situ* in large quantity on Law's Farm, three miles N.E. or N.N.E. of Kingston, on Lake Ontario, 200 miles to the E.N.E. of the spot on which they now lie. Others are Medina Sandstone, and angular masses of dark blue limestone from the Humber (eight miles west of Toronto, due north of the Niagara Falls), full of fossils,—*Mytilus* and *Strophomena*, characteristic of the Hudson group of sedimentary rocks.

The same rolled milky quartz and Humber limestone prevail in the debris lying in the fields on the west shore of Lake Ontario, both above and below the high ridge, which forms the continuation of Queenston Heights.

Lakes Ontario and Simcoe.—Lake Ontario is 234 feet above the sea, and 322 feet (330 feet, according to Mr. Logan) below Lake Erie. Almost everything is yet to be ascertained respecting the height and composition of the containing margin of Lake Ontario. One or two points of elevation only on the north and south sides are known with accuracy; the rest are estimates.

Two, three, or more lofty terraces or ridges, allowing a wide outlet on the north-east, wander round the lake at various distances, usually out of sight, but occasionally near.

The highest at present known on the north shore, in the rear of Toronto, is 680 feet above sea-level; and the highest on the south shore is 762 feet above the same base; the former is the estimate of Sir Charles Lyell, the latter according to the measurements of civil engineers.

With these few words premised, I shall proceed, as before, to extract from my own note-books.

On travelling from Toronto to Holland's Landing on Lake Simcoe, along Yonge Street, a distance of 37 miles, I found three boulders (one weighing a ton) of the mixed petalite, soon to be spoken of, at twelve and fourteen miles from Toronto. The fields between ten and eighteen miles from Toronto are tolerably free from boulders; but for the next eleven miles (to the twenty-ninth mile from Toronto) the boulders become abundant, and are gneiss, quartz-rock, syenite, coarse mica-slate, white marble, conglomerate of primitive rocks, the smooth brown Matchedash Limestone from the north of Lake Simcoe, and a limestone from the same vicinity, whose fossils are arenaceous casts.

From this point to Holland's Landing erratics become rare; but the eminences in the rear of the sandy flat upon which that hamlet is built are crowned with many large boulders. Erratics similar in kind to the foregoing also load the west side of the river all the way to

Lake Simcoe. Of Lake Simcoe I may here briefly say, that the west sides of Cook's Bay and Kempenfelt Bay, thirty-two miles from Holland's Landing, are encumbered to an extraordinary amount with very large and rounded erratics, derived from the N. and N.W., which extend also as far into the woods as we had time to venture. In the latter bay I saw much loose labradorite and most of the loose rocks that were seen at the Giant's Tomb. The bottom and north side of Kempenfelt Bay are faced with one or more high terraces—two at Johnsons; these are composed of sand and *rounded* stones.

I now return to Lake Ontario, and pass on for fifty miles along the high-road which skirts the lake, with many deviations, from Toronto to Kingston.

For several miles at first I passed through woods, growing on white sand and grey clay in various states of admixture. About the river Rouge (eighteen miles from Toronto) the land is covered with large primitive masses, and with much of the Simcoe Limestone, containing fossil-casts of loose yellow sand (found also *in situ* on Quinté Portage, Lake Ontario).

At thirty miles east of Toronto, about Still's Tavern, and so for many miles (to Farley's—forty-five miles? from Toronto), the country undulates greatly, and is full of ridges and misshapen deposits of gravel and sand. Here and there are flats, with winding terraces in their rear; running, however, with a certain parallelism to the lake-shore. Parts, especially the eminences, are loaded with boulders of primitive rocks, of sahlite, white marble, &c.,—very large, and of Simcoe limestone—the last not scattered about, but occurring in heaps.

I afterwards saw this instructive scene from the lake below, whilst making a coasting-voyage between Toronto and Kingston (180 miles), in a small boat.

On this occasion the following observations were made. On the beach in front of Toronto are many large erratics of syenite, greenstone, and labradorite, with a block (weighing more than two tons) of the mixed serpentine and marble, which is met with in the north, high up the Ottawa River.

Besides these, there is a remarkable block, not much rolled, which was first noticed by the late Dr. Lyons. It is a mass, weighing about two tons, consisting of an intimate mixture of calcspar, actinolite, and petalite. As it has been already described both chemically and mineralogically by Dr. Gerard Troost* from my specimens, I shall say no more about it here, further than to remark that most probably it has been derived from the north.

Toronto stands upon clay, which contains in spots many small pebbles of milky quartz.

Proceeding eastwards from hence six miles, we come to a line of cliffs, seven and a half miles long, called the Highlands of Toronto†. On the west they begin abruptly and loftily, at the eastern end of the deserted bay in which Toronto is situate; while their other ex-

* Journal of the Academy of Natural Sciences of Philadelphia, vol. iii.

† A noted land-mark on the lake.

tremity sinks gradually to the level of the lake. These cliffs, 250–300 feet high, are quite perpendicular and tolerably straight, but broken from time to time into ravines, with partially wooded slopes strewn with large erratics. The upper parts of the cliff are usually worn by rain and torrents into large triangular excavations, reaching only one-third of the way down; so that they resemble a line of houses, with the gables of their high-pitched roofs presented to the street, as customary in Holland. At the angles of the petty indents, they project into the lake in one, two, or three lofty, needle-like pyramids; the fissures being vertical.

The sand of these cliffs is yellow and fine; the clay is either white, or bluish or chocolate-black; both present thin horizontal layers, and often succeed each other in one or more broad bands.

The white clay, or marl (for it varies), is sometimes intimately mixed with small bits of bluish black limestone, not to be distinguished from the Niagara limestone; as well as with fine yellow sand.

I only landed twice, as we skirted close in shore; and, although I looked anxiously for organic remains of any kind, I found none. If there had been any large bones in the face of the cliff, I was always near enough to detect them, as I had done elsewhere. From these Highlands to Kingston, at the outlet of Lake Ontario, its immediate shores, when not mere marsh, are almost wholly earthy scarps, of heights varying from 5 to 80 feet; except at the angles of curvatures, where there is often a few fractured ledges of horizontal limestone. The same is the case on the south shore of this lake, especially about Sodus. Everywhere we have banks of earth, clay, and ferruginous sand, full of primitive and other boulders.

Halfway to Port Hope (sixty miles from Toronto) the naked loamy banks are filled with erratics. The terraces and other works of aqueous origin which I saw between thirty and fifty miles from Toronto, on my land journey, are often visible from the lake. They range at various heights along shore in great sweeps, overlooking extensive morasses. At a distance of forty-seven miles from Toronto, the scarped banks, 20–25 feet high, are altogether composed of extremely white sand, containing many erratics, especially of white quartz.

Three miles nearer Port Hope, they consist of loam and gneiss boulders.

About Port Hope, and for a few miles to the west, the lake is bordered by naked banks, 10–40 feet high; the lower half is clay, the upper half sand or sandy loam. The clay is in very thin horizontal layers, and is parted from the sand in waving lines.

On the beaches we have everywhere small limestone-shingle and large primitive blocks—marble, gneiss, &c.

Of the interval of about thirty-five miles between Port Hope and the Quinté Portage, I have only noted that for many miles west of the latter point, from time to time broken lines of old water-margins are visible on the rising coast, a hundred feet and more above the water, at different distances (100 or 1800 yards) into the country. They are short dilapidated terraces, patches of rock in low walls, ridges of naked boulders, or heaps of sand ranging along shore. They are particularly well-marked ten miles west of Presqu'isle.

From the Quinté Portage to Kingston, seventy-five miles, principally along the winding Bay of Quinté, gravel-banks prevail on the north mainland, which are full of rounded blocks of granite, greenstone, and gneiss. This is well seen in the Bay of Quinté, twenty-seven miles from Kingston, and at Adolphus Town.

I have visited the country in the rear of the Bay of Quinté for thirty or forty miles northwards. It contains the Trent and Moira Rivers, together with numerous lakes. Its erratics are in vast numbers, distributed equably. They are of all the usual sizes, and are gneiss, syenite, &c., derived from the north and north-east. In uncleared parts we meet with naked platforms of limestone, many acres in extent, on which we find these foreign blocks reposing.

Although I desire this Communication to appear mainly as a collection of facts, perhaps I may be permitted to make the following few observations;—first, on the *loose detritus*, small and large; and secondly, upon the *imbedded detritus*.

We have seen that the loose detritus of the Great Lakes may be arranged into three kinds:—

1. The distant erratics.
2. The near or lake erratics.
3. The native debris.

The condition and relations of the first kind are everywhere so similar, and their presence or range so extensive, that the producing agency must have been proportionately extensive, and probably of long continuance,—loaded ice-bergs, travelling from the north,—or an earthquake sea-wave with subsequent submergence.

The general courses of the boulders, &c., traced from their parent rocks, may be seen on the Map, Pl. XIV.; on which the courses of the scratches and boulders, as laid down by Prof. Hitchcock, and the tracks of the erratics observed by myself, are respectively shown. In my operations, I have been much aided by the occurrence of strongly characterized boulders, and by observations made during previous journeys that extended 400 miles to the north of Lake Superior, 150 miles north of Lake Huron, and 200 miles north of Lake Ontario.

The prevailing direction of the first, or *distant* class of erratics throughout the valley of the St. Lawrence, is southerly as far as is known. In Lake Huron many boulders have travelled S.S.E. In Lake Ontario, on the river St. Lawrence, both above and below Quebec, they have been carried W.S.W. contrary to the present current of that river.

The exact line of march cannot always be determined, from the great extent of the formations furnishing the boulders. I refer to gneiss, syenite, marble, &c. The white marble, for instance, occupies, on the north of Lake Ontario, two degrees of latitude and six of west longitude.

Boulders are distributed somewhat partially; certain areas have few or none; and this over the whole country generally, without reference to the present rivers and lakes. But they seldom fail on high grounds, such as the top of Cap Tourment, Lower Canada, 2100 feet above the sea,—on the high north mainland of Lake Superior,—and on the summit of Montreal Hill. Still they are in the greatest numbers—in quantities quite astonishing—at points of obstruction on all the Canadian rivers, whether caused by narrows, islands, rapids, or falls. They often overflow the vicinity of such spots, in like numbers, and without exhibiting much attrition. The smaller detritus has been driven by winds and rains into hollows, leaving the larger—the blocks—exposed and alone.

These distant erratics have, therefore, been in motion since the formation of the existing water-courses.

The second class, the *home or lake erratics*, are, perhaps, the products of causes now in operation,—frosts and thaws, freshets, storms. In all these Canadian lakes, at least along-shore, large fields of ice are formed, which entangle earthy matters of all sizes, and transport them here and there.

The cliffs and deep waters of the north side of Lake Superior are well-fitted for the lodgement of considerable masses of mixed ice and snow, which the warmth of summer would cause to drop into the lake, there to be for a time the sport of the winds. I saw snow on the heights of this lake in June, a month, indeed, in which it has been known to snow all day.

This class of erratics may radiate from a common centre, irrespective of present currents, as we see in the case of the jasper-pudding-stone, which we find forty or fifty miles on the east, west, and south of its parent-bed. It is possible that its boulders may also be found on the north, but I doubt it.

Fragments of the rocks of Lake Huron travel into Lake Superior, from the east;—strengthening the belief that these two lakes were once united;—a union, which, if Lake Huron were raised only ten yards, would be effected. At the Falls of the River St. Mary, connecting these two lakes, boulders from both meet in great numbers and size; these were left, perhaps, by opposing currents, independent of the watercourses we now have.

It was curious to trace the well-marked augitic trap of Montreal, stretching up the St. Lawrence, and occurring at successive distances until the last bit I observed was on the Genesee River, on the south shore of Lake Ontario, 270 miles to the S.W. The boulders of this rock are, however, in far greater quantity on the southern levels, between Montreal and Lake Champlain.

Canadian rivers annually bring down a certain quantity of detritus; and winds disperse fragments of ice-borne rocks over lake-shores; but in Lake Huron, at least, this latter operation goes on but slowly. The opposing beaches of two very narrow straits in Lake Huron (those of Pelletau, near St. Joseph Isle, and Lamorandière, Collin's Sound) are lined with totally distinct detritus. In like manner, among the incredible quantities of debris on the north shore of the

St. Lawrence, seventy miles below Quebec, I only found two small fragments of the inclined shale of the opposite shore.

In the Lake of the Woods, any existing current goes northwards, but it brings none of the innumerable loose masses of limestone of the south division of the lake into the northern part; but erratics of the latter are in millions in the south division. I think the present currents brought into Lake Erie only a small portion of the rocks of Lake Huron, as we now find them. Instances of well-known erratics having been shifted by the ice of winter, in lakes and streams, and on the sea-coast, have been already published by Mr. Logan, Mr. Holmes, myself, and others.

Twenty miles south of La Ronde in Lake Nipissing, and half a mile from the south shore, there is an example of one of those piles of square travelled rocks, similar to those observed by Sir Roderick Murchison on the rivers of Siberia*. There is another in Lake Croche, S. Hudson's Bay, two in Lake Huron, and one on the river Ottawa. That in Lake Nipissing consists of a large pell-mell heap of gneiss-slabs, with edges as sharp, and surfaces as clean as if they had been quarried yesterday for gravestones and flung down there. These must have been left on shallows by the ice during a spring-freshet.

Fig. 2.—*Profile of the west bank of the Ottawa River, below the Tesouac River (or Mattawa River); showing the ice-borne debris left after freshets.*

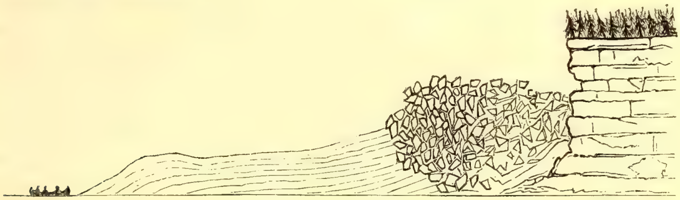


Fig. 2 represents a similar fact seen on the river Ottawa, a little below the river Mattawa or Tesouac, and about 320 miles above the St. Lawrence. It is a long line of naked square blocks, lying between the limestone cliff, bounding the river in spring, and the ordinary bed of the stream,—a deep hollow intervening.

It has been supposed by the Professors Rogers, I think, that there have been from the north two discharges of erratics under water, which were separated by a period of repose. I have no data for applying this idea to the Canadas.

The Imbedded Detritus. Beds and Terraces.—The Canadas, in common with all the western and northern parts of the United States, are mapped out by irregular concentric rings of terraces and ridges, sometimes hundreds of miles in circuit, which inclose the beds (with or without water) of lakes and ponds more or less closely. The mouths

* The Geology of Russia in Europe and the Ural Mountains.

of rivers here and there break through these rings; and the rivers themselves are also bordered with terraces.

Such appearances, either continuing into the adjacent countries, in the form of high plains, or sinking into swamps, constitute a far more striking feature in these regions than in England. To measure and delineate them would occupy a commission of geologists for years.

The deposits forming the terraces are composed of detritus, varying throughout the valley of the St. Lawrence with the locality,—a certain kind being confined to a certain district. They are mostly derived from the sub-rock, but mixed, as we have seen, with foreign matters.

This native debris, whether calcareous or metamorphic, is almost invariably gritty, in sharp-edged, lenticular pieces, as if it had been pounded.

The terraces are the margins of former bodies of water, much loftier and larger than those now existing. These ancient lakes have been more or less emptied by the elevation of their beds,—an elevation taking place, perhaps, very extensively, slowly, and variously. How and when the changes in level,—their degrees and sequences,—took place, I do not pretend to say.

Figs. 3 and 4 show the present levels of the region between Lake Michigan and the Gulf of St. Lawrence, and of that between Lakes Huron and Champlain. The lines of section taken are indicated on the general Map, Pl. XIV. These diagrams show also the positions and elevations of some marine and freshwater deposits; most of them were discovered by our associate Mr. Logan, but that at Montreal was first announced by the late Dr. Lyon, and that at Hull, on the Ottawa, by myself. We hereby see, that the land with its terraces, becomes higher as it recedes from the Atlantic; the ancient banks of Lake Superior being 930 feet above tide-water, which may or may not identify the waters depositing them with the sea; and thus they may have covered the Canadas, United States, &c.

These Lake Superior deposits, nevertheless, contain no organic remains, as far as is yet known; but, descending eastward into Lake Huron, we find extensive fresh-water beds on its east shore, 614 feet above the ocean; and another (or others) a few feet lower, on the river Detroit, on Lake Erie, and the river Niagara.

Descending from Lake Erie to Lake Ontario, we have another great set of concentric terrace-rings; these also are destitute of organic remains, and are supposed to be marine by the State Geologists of New York.

Two hundred miles nearer the sea, Mr. Logan found on the Lower Ottawa many and large deposits, side by side, both of fresh-water and marine shells, spread over a space 150 miles in length; and doubtlessly more are yet to be revealed, as clearances go on.

The marine shells of Montreal Hill are 460 feet (470 feet, according to Mr. Logan) above the sea—while about a mile on their south, some hundred feet below, is a bed of fresh-water shells, in which the horns of a large land-animal have been found.

Levels of Freshwater and Marine Deposits in the Canadas,—from the Sea, inland.

Fig. 3.—*Section E.N.E. from Lake Michigan to River du Chat (Gulf of St. Lawrence). About* 900 *miles direct.*

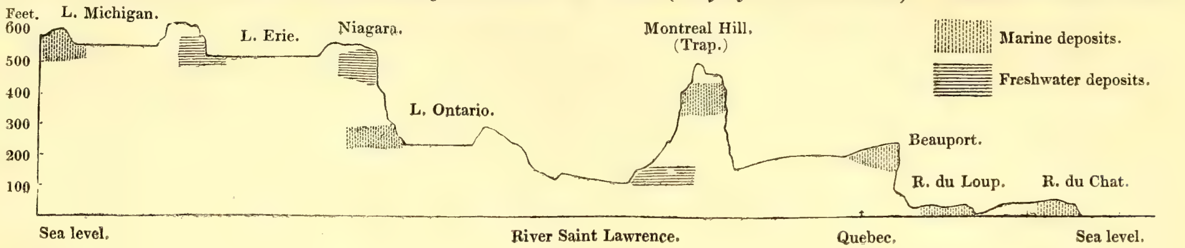
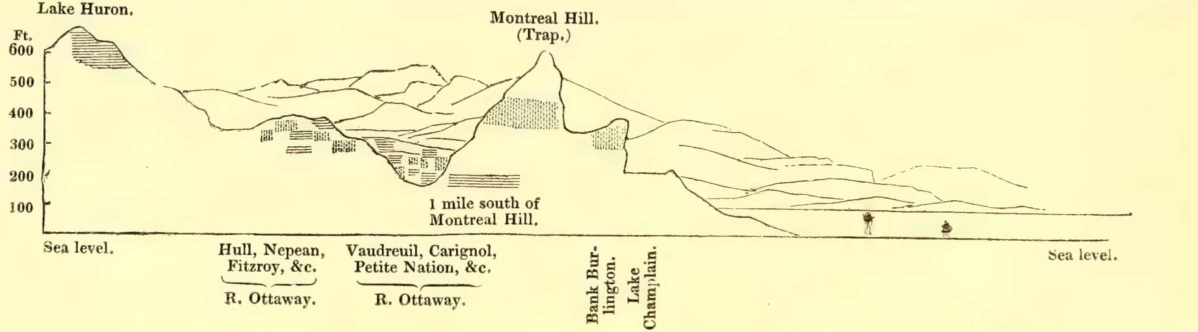


Fig. 4.—*Section, nearly E. and W., in a direct line from Lake Huron to Montreal and Lake Champlain;* 260 *miles.*



Is it to be supposed that each marine formation was laid down at the present sea-level, and then raised, or that each marks the sea-level of an unknown epoch?—and that fresh-water deposits were made at various levels above the sea?

Vertical oscillations of the land are very general. Mr. Logan discovered in St. Armand fresh-water shells incumbent on marine.

Lastly, in the Gulf of St. Lawrence, we find ancient marine formations at only 20, 30, and 40 feet above present tide-level.

April 30, 1851.

John Edward Hutchins, Esq., M.P., was elected a Fellow.

The following communications were read:—

1. *Notice of the Occurrence of an* Earthquake *at* Carthagena, New Granada, *on 7th February*, 1851.

[Communicated from the Foreign Office by order of Viscount Palmerston.]

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2. *On* Fossil Rain-marks *of the* Recent, Triassic, *and* Carboniferous Periods. By Sir Charles Lyell, F.R.S., G.S.

Mr. John Cunningham, F.G.S., in the year 1839, read a paper before the Geological Society on Impressions and Casts of Drops of Rain discovered in the quarries of Lower New Red Sandstone at Storeton Hill, Cheshire*. After he had inferred their pluvial origin, he pointed out the indentations on the spot to Dr. Buckland, who recognized the correctness of his interpretation.

When, in 1841, I visited the quarries of new red sandstone at Newark, in New Jersey, in company with Mr. W. C. Redfield, of New York, we observed some very distinct rain-prints on ripple-marked shales. Afterwards, in 1842, I saw similar impressions of recent date, which had been made between high- and low-water mark on the red sand and mud bordering the Basin of Mines, in the Bay of Fundy. Since that period I have been enabled to form a collection of specimens of this mud, hardened in the sun, through the kindness of Dr. Webster of Kentville, to which I shall presently allude. In 1843, Mr. Redfield, in a letter to the author which was read to this Society, stated that he had found impressions of rain-drops in another locality of the new red sandstone, called Pompton, in New Jersey, twenty-five miles from New York†; and in the same year he published in Silliman's Journal an account of the sandstone strata of that place, and of the Ichthyolites contained in them‡. In these beds, many of which are frequently ripple-marked, and which exhibit the foot-prints of

* Proceedings Geol. Soc. vol. iii. p. 99. † Ibid. vol. iv. p. 23.

‡ Amer. Journ. of Science, vol. xliv. p. 136.

birds, shrinkage-cracks are seen, together with fossil impressions and casts of rain-drops and of hail.

Early in the present year I received from Mr. Richard Brown some fine specimens of rain-marks from the greenish shales of the coal-measures of Cape Breton, Nova Scotia, to which he has made a passing allusion in his excellent description of the Sydney coal-field in our Quarterly Journal*. A comparison of all these specimens has convinced me that the impressions of triassic and carboniferous date, above mentioned, have been correctly referred to the action of rain, and that they are distinguishable from such cavities as are sometimes made by the rising of air-bubbles through mud or sand, with which Mr. Desor, in a memoir recently published, has declared many, if not all, the supposed fossil rain-marks to have been confounded†.

Recent Rain-prints of the Bay of Fundy.

In my 'Travels in North America'‡ some notice is taken of the peculiar combination of circumstances which render the mud-flats, exposed at low-tide in the Bay of Fundy, so peculiarly fitted to receive and retain the foot-prints of animals, or any impressions which may happen to be made on their surface. The sediment with which the waters are charged is extremely fine, being derived from the destruction of cliffs of red sandstone and shale, belonging chiefly to the coal-measures. On the borders even of the smallest estuaries communicating with a bay, in which the tides rise sixty feet and upwards, large areas are laid dry for nearly a fortnight between the spring and neap tides, and the mud is then baked in summer by a hot sun, so that it solidifies and becomes traversed by cracks, caused by shrinkage. Portions of the hardened mud may then be taken up and removed without injury. On examining the edges of each slab, we observe numerous layers, formed by successive tides, usually very thin, sometimes only one-tenth of an inch thick,—of unequal thickness, however, because, according to Dr. Webster, the night-tides, rising a foot higher than the day-tides, throw down more sediment. When a shower of rain falls, the highest portion of the mud-covered flat is usually too hard to receive any impressions; while that recently uncovered by the tide near the water's edge is too soft. Between these areas a zone occurs, almost as smooth and even as a looking-glass, on which every drop forms a cavity of circular or oval form, and, if the shower be transient, these pits retain their shape permanently, being dried by the sun, and being then too firm to be effaced by the action of the succeeding tide, which deposits upon them a new layer of mud. Hence we often find, on splitting open a slab an inch or more thick, on the upper surface of which the marks of recent rain occur, that an inferior layer, deposited perhaps ten or fourteen tides previously, exhibits on its under side perfect casts of rain-prints, which stand out in relief, the moulds of the same being seen on the layer below. But in some cases, especially in the more sandy layers, the markings have

* Vol. vi. p. 119.

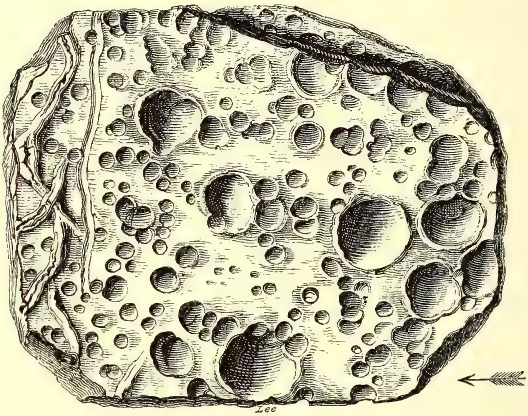
† Edinb. New Phil. Journ. for 1850, p. 246.

‡ Vol. ii. p. 126.

been somewhat blunted by the tide, and by several rain-prints having been joined into one by a repetition of drops falling on the same spot; in which case the casts present a very irregular and blistered appearance. Dr. Webster has also sent me some specimens, showing the result of long-continued rain, in which all signs of circular or oval cavities have disappeared, and where no one would suspect the pluvial origin of that slight unevenness which may still be traced on the otherwise level surface.

The finest examples of rain-prints sent to me from Kentville were made by a heavy shower, which fell on the 21st of July, 1849, when the rise and fall of the tides were at their maximum in that small estuary which opens into the Basin of Mines. The impressions (see fig. 1) consist of cup-shaped or hemispherical cavities, the largest being

Fig. 1.—*Recent Rain-prints, formed July* 21, 1849, *at Kentville, Bay of Fundy, Nova Scotia.*



The arrow represents the direction of the shower.

fully half an inch in diameter, and from one-tenth to one-sixth of an inch deep; but there are very few of such dimensions. The depth is chiefly below the general plane of stratification, but the walls of the cavity consist partly of a prominent rim of sandy mud, formed of the matter which has been forcibly expelled from the pit, and this margin or lip sometimes projects as much above the plane of the stratum as the bottom of the pit extends below it. The rim of the largest rain-prints is sometimes no less than one-twelfth of an inch broad, but it is usually much narrower. The outer side of it is often perpendicular or almost overhanging. In the same shower in which the largest drops are half an inch in diameter, the average impressions are only from one-eighth to one-tenth of an inch across. Many of every size are circular, but others are oval, the largest diameter exceeding the shortest by one-third or one-fifth. All the cavities having an elliptical form are deeper at one end, where they have also a higher rim, and all the deep ends have the same direction, showing towards which quarter the wind was blowing. Two or more drops are sometimes seen to have interfered with each other; in which case it is usually possible to determine which drop fell last, its rim being unbroken.

On some of the specimens the winding tubular tracks of worms are seen, which have been bored just beneath the surface (see fig. 1). They occasionally pass under the middle of a rain-mark, having been formed subsequently. Sometimes the worms have dived beneath the surface, and then reappeared. Occasionally the same mud is traversed by the foot-prints of birds (*Tringa minuta*) and of musk-rats, mink, dogs, sheep, and cats. The leaves also of the elm, maple, and oak trees have been scattered by the winds over the soft mud, and, having been buried under the deposits of succeeding tides, are found on dividing the layers. When the leaves themselves are removed, very faithful impressions, not only of their outline, but of the minutest veins, are left imprinted on the clay.

On one specimen of dried mud from Kentville I observed numerous small protuberances which on a hasty view seemed not unlike the casts of rain, but which I satisfied myself could not be such, because they stood out in relief from the upper surface of the mud, on which foot-marks of birds were *indented*. On examining this slab more closely, the protuberances were seen to be irregular in form, and beneath them were found small pellets of shale and crystals of salt, which had evidently lain on the beach, and then been covered with a film of sediment. This solid matter not having shrunk when the muddy layer dried in the sun, a small projection was caused. Small cracks were usually visible round the base of each of these protuberances.

Another set of small convexities, also protruding from the upper surface of the mud, proved to be the crusts of small cavities, each cracked at the top, and were suspected by Mr. Faraday, to whom I showed them, to be bubbles of mud which had dried without bursting. He succeeded in producing similar convex protuberances experimentally, by pounding up the Kentville mud, moistening it with water, and then, by means of glass tubes, introducing air below, which rose to the top in bubbles. Some of these being dried, consolidated without breaking, until finally the crust which covered the cavity where the air had been imprisoned, cracked at the top on shrinking, like the convex protuberances from the Bay of Fundy.

Being desirous of ascertaining whether air-bubbles, rising through mud and bursting as they reached the surface, could give rise to cavities similar to those caused by the fall of rain, I poured some pounded mud from Kentville on a small quantity of water, and shook the basin containing it, upon which numerous bubbles of entangled air rose through the mud, and, on bursting at the surface, left cavities resembling in size the ordinary rain-prints from Nova Scotia, but very different in character. Nearly all of them were perfectly circular, with a very sharp edge, and without any rim projecting above the general surface. In a few cases, however, there was a slight, narrow rim, sharper and more even than that of a rain-print. In no instance was this rim connected with a greater depression at one end of an oval concave depression. Most of the pits produced by these air-bubbles were different also from rain-prints, in being deeper than they were wide. Their sides were very steep, and often overarching, the cavity below the surface being wider than the opening at the top. The axis of some few of these deeper cavities was oblique to the surface of the mud. Where two bubbles had touched, a vertical thin parting wall of mud was left between them.

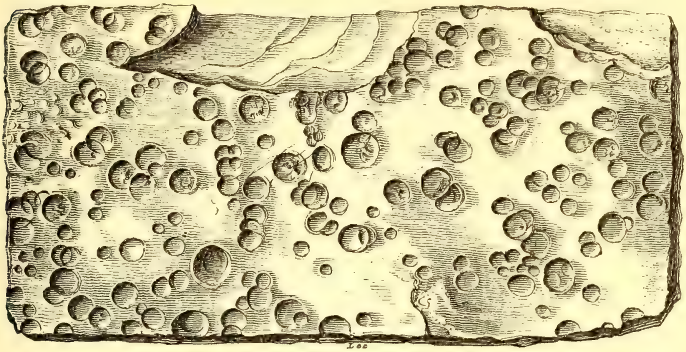
I also exposed the same mud in a soft state to a shower of rain, and reproduced markings like the smaller rain-prints which had been sent me from the Bay of Fundy. By causing single large drops of water to fall from a sponge upon the same mud from a height of about ten feet, circular pits were formed, similar in size and depth to the largest impressions of rain from Kentville, and having similar rims.

The occasional discovery of a few isolated cavities of the size of rain-prints in ancient strata, seems to have led some geologists to ascribe them to air-bubbles, simply on the assumption that rain would cause the mud or sand to be pitted all over by numerous impressions. But, if the hollows have characters proper in other respects to rain-prints, we ought not to seek for a distinct cause, even although only one or two may appear on a wide area. I saw such isolated cavities, which I feel sure were due to the fall of drops of water, on dried mud on the beach at Baltimore in 1842, and brought away with me a solid specimen. A few heavy drops from a thunder-shower, which had spent its force elsewhere, may have caused them; or one of the numerous water-birds which were flying about the shore may have let fall a drop of salt-water from its wing, or from a fish which it was carrying off in its mouth.

Triassic Rain-prints.

I have alluded to my visit to the quarries of New Red Sandstone or Trias at Newark, in New Jersey, in 1841, where rain-prints occur, and to still finer examples observed by Mr. Redfield in the same formation at Pompton, in New Jersey. In that locality many of the layers of red shale or red clay are ripple-marked and traversed by shrinkage-cracks, and exhibit the foot-prints of tridactylous birds, so common in the shale and sandstone of the valley of the Connecticut. In their average size these ancient rain-prints agree with those of modern date, although none of them equal the largest of those, before mentioned, from the Bay of Fundy. As in specimens of recent mud from Kentville, the triassic strata exhibit every gradation from transient rain, where a moderate number of drops are well preserved (see fig. 2), to a pelting shower, which by its continuance has almost obliterated the circular form of the cavities. In the more perfectly preserved examples, smaller drops are often seen to have fallen into cavities previously made by larger ones, and to have modified their shape. In some cases of partial interference, the last drop has obliterated part of the annular margin of a former one; but in others it has not done so, for the two circles are seen to intersect each other. Most of the impressions are elliptical, having their more prominent rims at the deeper end. We often see on the under side of some of

Fig. 2.—*Rain-prints on red shale, from the New Red Sandstone or Trias of Pompton, New Jersey, U. S.*—W. C. Redfield.



these slabs, which are about half an inch thick, casts of the rain-prints of a previous shower, which had evidently fallen when the direction of the rain was not the same. Mr. Redfield, by carefully observing the obliquity of the imprints in the Pompton quarries, ascertained that most of them implied the blowing of a strong westerly wind in the triassic period at that place. The form of the undulating surface, or the ridges and furrows of the ripple, has sometimes modified the depth of the impressions, which are fainter on the lee-ward side of each ridge and stronger on the windward slope of the same.

One class of superficial indentations at Pompton has, I believe, been correctly referred by Mr. Redfield to hail. These hail-marks (see figs. 3 and 4) are deeper and much more angular and jagged in

Figs. 3 & 4.—*Supposed Hail-prints on red shale, from Pompton, New Jersey.*—W. C. Redfield.

Fig. 3.

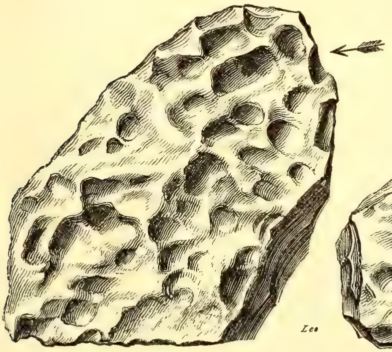
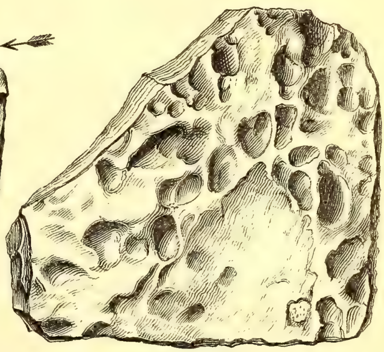


Fig. 4.



their outline than rain-prints, and have the wall at the deepest end more perpendicular, and occasionally overhanging. Fossil fish, belonging to the genus *Ischypterus*, Egerton, are found in the red sandstone at Pompton.

As some geologists imagine that a great part of the impressions, imputed to rain, may have been simply the effect of air-bubbles rising through mud, I may state that I agree with Mr. Redfield in thinking that, in such examples as those above-described, no practised observer can fall into a mistake. The oval form of so many of the cavities, and their greater depth at one end, are characters alone sufficient to prove the real origin of the imprints on the Pompton shales. It has indeed been objected that where triassic shales alternate with quartzose sandstones, as at Storeton Hill, on the Mersey, near Liverpool (a spot which I have myself visited), we might have expected the rain-marks to have been more blunted by a current of water having exerted sufficient power to spread grains of sand over a large surface of mud. Mr. Cunningham gave an answer by anticipation to this objection, by suggesting that the fine sand of the white quartzose sandstone, in which the casts of rain-prints are preserved, may have been blown by the wind over an area which we may infer to have been above water at the time, because of the depth of the Cheirotherian footprints traversing the rain-marked layers. I have noticed in my 'Travels in North America,' that on the beach at Beauly, in the delta of the Savannah river, in Georgia, I saw numerous foot-tracks of racoons and opossums made on the sandy mud, where the animals had come down to the sea-shore to feed on oysters. These trails had been formed during the four preceding hours or after the ebbing of the tide. The surface of the mud had, by exposure to the air and sun, already acquired in that short time a considerable degree of firmness and consistency, and, while some of the moulds remained empty, others were half-filled with fine blown sand, which had already quite covered up a portion of each trail. The quartzose sand was in this instance derived from a low cliff, formed of tertiary strata so incoherent that clouds of minute grains were swept along by a gentle wind, —admirably exemplifying a process by which perfect casts of footmarks or of rain may be taken in a matrix capable of being afterwards converted into the hardest quartzose sandstone*.

Carboniferous Rain-prints.

In the sixth volume of the Quarterly Journal of the Geological Society, Mr. Richard Brown communicated to us an accurate and detailed account of the Sydney coal-field in Cape Breton, Nova Scotia. In that paper he called our attention to the occurrence in the coal-measures of thirty underclays with *Stigmaria*, and eighteen examples, at different levels, of the fossil trunks of trees standing erect, or perpendicular to the inclined planes of stratification, the greater part of the trees having their roots attached. Together with these proofs of the existence of forest-covered land on that area at different periods during the accumulation of the coal, he has described several intercalated strata of a marine or brackish-water character. We are pre-

* Travels, vol. i. p. 166.

pared, therefore, to hear of the discovery in such a region of the signs of all the phænomena which characterize sea-beaches or banks of sand or mud laid dry between high and low water. Accordingly Mr. Brown alludes in his memoir not only to ripple-marked surfaces and shrinkage-cracks, but to fossil rain-prints, and of these last he has had the kindness to send me some fine examples, which I shall now describe. They consist of delicate impressions on greenish slates (see fig. 5),

Fig. 5.—*Carboniferous Rain-prints, with Worm-tracks, on green shale, from Cape Breton, Nova Scotia.*—Richard Brown.

Fig. 6.—*Casts of the same Rain-prints as No. 5, seen on the under side of an incumbent layer of shale.*

Fig. 5.

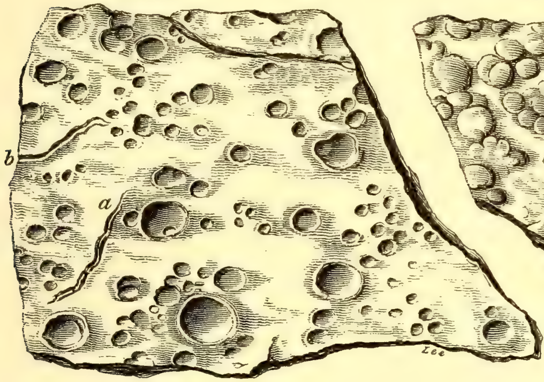
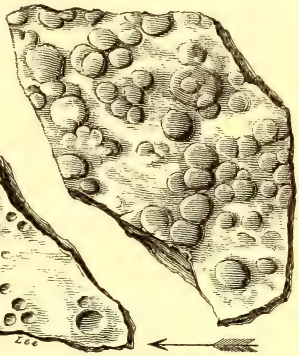
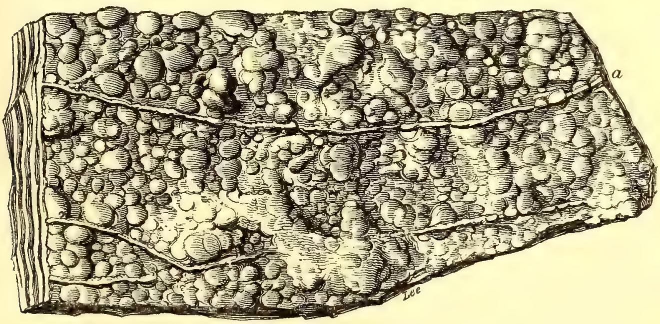


Fig. 6.



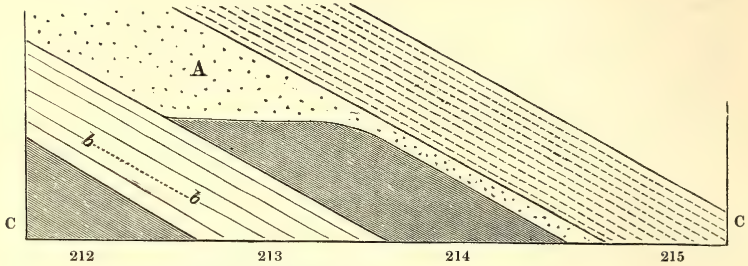
and of casts projecting from the under side of similar shale resting upon them (see fig. 6). Some of these casts present the same warty or blistered surface (see fig. 7) which Mr. Cunningham has mentioned,

Fig. 7.—*Casts of Carboniferous Rain-prints and Shrinkage-cracks on the under side of a layer of sandstone, Cape Breton, Nova Scotia.*—Richard Brown.



when speaking of the Storeton Hill rocks. Some of the Cape Breton specimens came from the bed No. 213 of the section published in our Quarterly Journal*. In the annexed diagram, fig. 8, Mr. Brown

Fig. 8.—*Section showing the position of Rain-prints* (*b, b*) *in the inclined Coal-measures of Cape Breton, Nova Scotia.*—Richard Brown.



b, b. Position of the Rain-prints.
C, C. High-water mark.
212. Red shale.
213. Greenish arenaceous shales with Rain-prints.
214. Red shale.
A. Sandstone, the upper layers of which pass over the red shale 214.
215. Arenaceous shale.

has been enabled to give, in consequence of the altered state of the cliffs, a more correct representation of the beds containing rain-prints than that before published, for he has discovered that the upper layers of sandstone, A, about 1 foot in thickness, spread over the shale 214, towards the dip. The exact position of the rain-drops in the laminated and rippled arenaceous shale, No. 213, is indicated in the annexed diagram, at *b. b.* fig. 8. Some of the layers in No. 213 consist of almost pure sandstone. Here, as in another instance in the same line of coast, the rain-prints, which are very perfect in a higher part of the cliff, become first indistinct lower down and then disappear, showing, says Mr. Brown, that they constituted originally a narrow zone, as they would naturally do on a sea-beach. In the drawing given of some of these drops (fig. 5), many of them are seen to be very oval in form, and their deepening at one end shows the direction of the wind, as indicated by the arrow.

In the same manner as in the recent mud of the Bay of Fundy, the tracks of annelids are seen in the carboniferous shale on the same surface with the rain-prints (see fig. 5), and some of the ancient worm-tracks disappear and rise again to the surface as do those of modern date. A drawing is also annexed of one of the sandstones from Cape Breton (fig. 7), with casts both of rain-prints and of small cracks, which must have traversed the subjacent clay on which the rain fell.

In re-examining the slab figured in my 'Second Visit to the United States†,' which I brought in 1846 from the coal-strata of Greensburg, Pennsylvania, on which Dr. King found impressions of a car-

* Vol. vi. p. 119; not in No. 214, as was there stated by mistake.
† Vol. ii. p. 306.

boniferous reptile*, I find not only shrinkage-cracks, but a multitude of small tubercles covering a part of the surface, much resembling the casts of rain-prints, and which I strongly suspect to have been due to pluvial action.

The luxuriant vegetation of the coal-period, and especially the continuity of its forests for hundreds of miles, as well as the botanical character of its flora, had previously led botanists to infer a humid climate,—still it is satisfactory to obtain positive proofs of showers of rain, the drops of which resembled in their average size those which now fall from the clouds. From such data we may presume that the atmosphere of one of the remotest periods known in geology corresponded in density with that now investing the globe, and that different currents of air varied then, as now, in temperature, so as to give rise by their mixture to the condensation of aqueous vapour. The hail, moreover, of the triassic period, if correctly deciphered by Mr. Redfield (which I see no reason to question), affords another point of analogy between the meteoric agency of ancient and modern times, implying that certain regions of the atmosphere were occasionally intensely cold.

Since the above was in type, my attention has been called to a notice by Dr. Buckland, "On cavities caused by air-bubbles on the surface of soft clay," which, he justly observed, "must be carefully distinguished from impressions made by rain†."

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3. *On the Occurrence of a* Track *and* Foot-prints *of an* Animal *in the* Potsdam Sandstone *of* Lower Canada. By W. E. Logan, Esq., F.G.S.

When in England, about eight years since, I exhibited to the Society a specimen, brought by me from Horton, near Windsor, in Nova Scotia‡, which was considered to be the first faint evidence of the existence of reptilian animals, previous to the deposit of the Magnesian Limestone. Various fossils which were brought from the same locality, and others from Windsor, induced Mr. Lonsdale to think that the rocks were of the Triassic period, and M. De Verneuil, who had just returned from Russia with Sir R. Murchison, that they were Permian; but in a subsequent collection, brought by Sir Charles Lyell from the same place, the same palæontologists met with several Carboniferous forms; and Sir C. Lyell's evidences, communicated by him to the Society, left little doubt that the Horton and Windsor beds were of the Carboniferous age. By a subsequent careful examination of the great carboniferous development at the Joggins, on the Bay of Fundy, I satisfied myself that these reptilian traces occurred near the very base of the carboniferous deposit, as the equi-

* See Anniversary Address of the President, 1851, p. lvii.

† Report of Brit. Assoc. 1842, Trans. Sect. p. 57.

‡ See Proceed. Geol. Soc. vol. iii. p. 712.

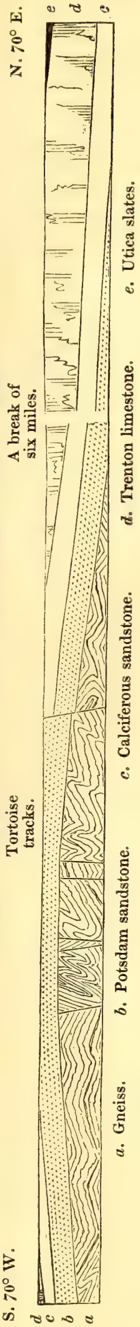
valent beds were there found to emerge from beneath 14,700 feet of carboniferous strata. Later discoveries by Dr. King* and Mr. Lea in Pennsylvania give clearer evidences than the Horton specimens of similar facts.

On the present occasion I have to place before the Society specimens which, interpreted by Professor Owen, who has had the kindness to examine them, appear to carry traces of the same class of animals still farther down in the series of geological formations,—in fact, to the very lowest rock that in America (up to the present time) gives signs of created beings. The specimens consist of a small slab of sandstone, showing foot-prints on one of its surfaces, and a plaster-cast from a longer surface of a similar description. The original is in the museum at Montreal connected with the Geological Survey of Canada. It would have been more satisfactory to have exhibited the original than the cast; but as the former weighs upwards of a ton, I could not conveniently carry it with me across land to the sea-board at Boston, where I embarked; and as it was quarried out of its bed only in December last, after all the vessels had left the St. Lawrence, there has occurred no opportunity of transporting it by water.

My attention was first drawn to the track by Mr. Abraham, then editor of the Montreal Gazette, who duly appreciated its possible geological importance, and inserted a notice of it in his daily journal. The locality is on the left bank of the river St. Louis, at the village of Beauharnois, on the south side of the St. Lawrence, about twenty miles above the city of Montreal [see Map, Pl. XIV.]. The track occurs in a quarry where the rock, like the portion exhibited, is hard and fine-grained, in some parts approaching quartz-rock, and so siliceous, that similar material is used at Vaudreuil, a few miles distant, in the manufacture of glass. The rock is thick and close-bedded, with very thin partings, most probably of argillaceous material, between the layers, and the surfaces of the beds have a slight yellowish tinge from the presence of a small quantity of peroxide of iron. The surface displaying the impression was uncovered in the progress of quarrying the stone for building purposes. The most western portion of what was exposed is that removed to Montreal, like the plaster-cast, measuring 12½ feet in length. For about 50 or 60 feet beyond this, the overlying bed still conceals the track, which becomes exposed again for about as much more, the whole being in a pretty straight line, with very slight sinuosities similar to those in the cast. At some distance from this track there is another of the same character; but I am not quite sure whether it is on the same surface. I saw it in the spring, but in December I could not identify the spot, a freshet which had occurred having left a slight deposit covering it up. My quarryman subsequently ascertained its position, and will point it out on my return.

The general geological structure of the district in which the quarry lies is very simple. It had been ascertained in the progress of the Survey, previous to my becoming acquainted with the impressions, and is alluded to in two separate Reports of Geological Progress pre-

* See Anniversary Address of the President, 1851, p. lvii; and *supra*, p. 246.



Section of the Lower Silurian Rocks of Lower Canada, from the Cedars Rapid to Sault St. Louis.
Horizontal scale, 3 miles to 1 inch. Vertical scale, 1 mile to 2 inches.

sented to the Provincial Government—those for 1845–6 and 1847–8. From these and from the distribution of the rocks in New York, as mapped and published by the State Survey, the structure will be easily understood. In Canada, a formation, consisting of gneiss and interstratified crystalline limestone, sweeps through the province on the north side of the St. Lawrence and its lakes, from Lake Huron to Labrador. Below Cape Tourment its southern limit lies close upon the river, but above the Cape keeps at a variable distance from it in all parts, with the exception of the Thousand Islands, below Kingston, where the gneiss crosses the river to form a junction with a great peninsula-shaped area of the same, lying between Lakes Champlain and Ontario. Upon this formation along its whole contour rest the Lower Silurian deposits, the base of which, in the district more immediately requiring description, makes an elbow at the division-line between the counties of Franklin and Clinton, in New York, not far from the northern limit of the State, where the deposits turn from the valley of the St. Lawrence to that of Lake Champlain, the dip on one side of the turn being to the north-west, and on the other to the east. In the Canadian distribution of the same deposits, after following the valley of the St. Lawrence from Cape Tourment to St. Jerome, with a south-easterly dip, they turn to that of the Ottawa with an east of south dip, forming a less acute elbow than the former, with a contrary bend. These two elbows are directly opposite to one another, and the distance between them, from the gneiss on the one side to the gneiss on the other, is about fifty-eight miles, and, as might be anticipated from the arrangement, a flat saddle-shaped anticlinal form (the dip being everywhere very small) extends between them; it brings to the surface a long belt of the Potsdam Sandstone, which runs upon it for forty miles, until meeting with a protruding mass of gneiss in Mont Calvaire, which it surrounds. This belt is flanked on either hand by the Calciferous Sandstone and Trenton Limestone, the latter containing abundance of characteristic fossils, such as *Chætites petropolitanus, Leptæna sericea, L. deltoidea* or *euglypha, Orthis testudinaria, Spirifer lynx, Calymene senaria.* The beds in which the track occurs are nearly flat; they have, however, a dip to the eastward, which is towards the limestone, the nearest development of which is about a mile distant. Near Beauharnois the breadth of the Potsdam belt is about five miles, and from this position it gradually widens to the southward, the rock being traceable by many exposures, some of them of considerable extent, on the one hand all the way to Keesville, where it holds *Lingula antiqua*, and on the other to Potsdam and farther to Hammond, where, as well as at Alexandria, *Lingula prima* is met with, these *Lingulæ* being hitherto considered the most ancient evidences of organic life in America.

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4. Description *of the* Impressions *on the* Potsdam Sandstone, *discovered by* Mr. Logan *in* Lower Canada. By Prof. Owen, F.R.S., G.S.

The evidence of the track and foot-prints submitted to my examination by Mr. Logan consists of a slab of the sandstone with eighteen impressions of the right fore and hind feet, and ten of the left fore and hind feet, with a faint trace of a broad track between them, and of six casts in plaster of Paris (each cast being twenty-six inches by fifteen inches) of successive portions of the impressed rock, and each cast exhibiting from twenty-six to twenty-eight impressions of both the right and the left feet, with the broad and shallow median channel better marked in most of the casts than on the portion of the sandstone. The successive foot-prints are more numerous than any which have been previously discovered, and the circumstance of the corresponding prints recurring at regular intervals affords the strongest proof of their having been made by successive steps.

The foot-prints are in pairs, and the pairs extend in two parallel series, with the channel exactly midway between the right and left series.

The outer impression of each pair is the largest, being about an inch in diameter, and is commonly a little behind the inner one, which is about eight lines in diameter. Both are short in proportion to their breadth, with faint indications, in some, of divisions at their fore-part.

The two prints forming the pairs here and there are confluent or touch each other, but are commonly from four to six lines apart; and the pairs of the same side succeed each other at intervals varying from one inch and a half to two inches and a half, the common distance being about two inches. The interval between the right and left pairs, measured from the inner border of the small prints, is three inches and a half, and from the outer border of the large prints is seven inches. The median track is one inch and a quarter in breadth, and sinks about two lines below the surface where deepest impressed; varying in depth, but not in its relative position to the right and left foot-prints; and being deepest where the pairs of foot-prints are confluent and at shortest intervals; at which parts the median channel is seen to sink down more steeply at its sides than towards the bottom.

The inference to be deduced from the above characters is, that the impressions were made by a quadruped with the hind feet larger and somewhat wider apart than the fore feet: with both hind and fore feet either very short, or prevented by some other part of the animal's structure from making long steps; and with the limbs of the right side wide apart from those of the left; consequently that the quadruped had a broad trunk in proportion to its length, supported on limbs either short or capable only of short steps, and with rounded and stumpy feet, not provided with long claws. There are faint traces of a fine reticulate pattern of the cuticle of the sole at the bottom of some of the foot-prints on the portion of sandstone; and the surface of the sand is generally smoother there than where not impressed, which, with the rising of the sand at the border of the prints, indicates the weight of the impressing body. The median impression may be interpreted as due either to the abdomen or the tail of the animal. If to the latter, the tail must have been very thick, more depressed, or flattened horizontally, than rounded, and not compressed or carinate below, as in the tails of the *Crocodilia* and aquatic *Batrachia*. From the breadth of the impression a corresponding great length of tail might be inferred from the analogy of the *Reptilia*; yet there is no indication of any bending or movement of such a tail from side to side; and an additional element for guiding our choice from the two hypotheses of the cause of the median track is afforded by the fact that, throughout the great length of the trail of the quadruped, as exhibited by the plaster-casts, the median track never curves in any degree nearer to the right or the left foot-prints, but preserves an exact mid-distance between them.

As the shape of the body and the nature of the limbs indicated by the foot-prints accord best with those of the Chelonian reptiles of the 'estuary,' 'fresh-water,' or 'land' families,—the shape of the foot-prints being decisive against the marine species,—the median groove may have been scooped out of the soft sand by the hard and prominent median surface of a plastron. If this were so, it may be inferred that the species was a fresh-water or estuary tortoise rather than a land-tortoise, the true *Testudines* carrying their trunk higher when they walk than the more depressed *Emydes* do, and some of them having the plastron concave on its under surface; whereas in the flatter *Emydes*, as *e. g. Emys speciosa*, the middle of the fore-part of the plastron projects: and I am disposed to infer a plastron to have made the impression rather than a tail, not only from the shape of the impression, and its constant relative position to the legs, but also from the fact of its being deepest where, from the more confused or crowded grouping of the foot-prints, the animal appears to have been moving more slowly or resting: where the foot-prints are better defined, and indicate a steady rate of progress, the median impression is fainter, as if the trunk had been better lifted from the ground; and I may remark, that the difference in the size of the fore and hind feet is such as we find in some existing Terrapenes, *e. g.* the *Emys geographica*.

The more obvious inferences are the same which are deducible from other foot-prints in sandstone, viz. that the animal which made them was walking in air. In the present instance it is plain that they were not left by an amphibious fish, such as the sand-hopping *Lophiidæ*, but by a veritable air-breather; and they must have been made under those circumstances so well explained by Sir Charles Lyell, in his paper on Recent and Fossil Rain-prints (*vide supra*), as being essential to their preservation, viz. on an extent of sandy shore lying between high and low water mark.

Amongst the air-breathing classes of *Vertebrata*, the shortness of the steps and the median track of the impressions in question point plainly to the *Reptilia*; and here, from the breadth and shortness of the body, our choice lies between the *Batrachia* and *Chelonia*; and, on the grounds assigned in the above description of the tracks, I incline to refer them to a species of Terrapene or Emydian Tortoise.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

January 1st to March 31st, 1851.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Académie Royale des Sciences de Paris, Comptes Rendus de l'. Tome xxxi. nos. 22–27, Deux. Sem., and tome xxxii. nos. 1–6, Prem. Sem.

———. Mémoires, tomes xx. xxi. and xxii.

———. Mémoires présentés à l'Institut par divers savans, tomes x. and xi.

American Journal of Science. Second Series, vol. xi. no. 31.

Athenæum Journal, January and February.

Belgique, Académie Royale de. Mémoires, tome xxv.

Berg- und Hütten-männische Zeitung, mit besonderer Berücksichtigung der Mineralogie und Geologie. No. 1, 1851.

Berwickshire Naturalists' Club, Proceedings. Vol. iii. no. 1.

Bombay Branch, Royal Asiatic Society Journal. Vol. iii. no. 13.

Breslau, Akademie der Naturforscher, Verhandlungen. Vol. xxii. part 2.

———. Uebersicht.

Cambridge Philosophical Society, Transactions. Vol. ix. part 1.

Chemical Society, Quarterly Journal. No. 12.

Cornwall Geological Society, Royal. 37th Annual Report.

Dublin Geological Society, Journal. Vol. iv. part 2. no. 2.

Ecole des Mines, Annales. Quatrième Série, tome xvii. livr. 2 & 3, and tome xviii. livr. 4 & 5.

France, Dépôt de la Marine. Annales Hydrographiques, tomes ii. & iii., and Annuaire, 1850.

———. Instruction pour aborder et franchir la Barre de Bayonne.

———. Renseignements sur la Partie de la Côte occidentale d'Afrique.

———. Société Géologique de, Bulletin. Deux Série. Tome vii. F. 31-38.

Horticultural Society, Journal. Vol. v. part 4, and vol. vi. part 1.

Indian Archipelago, Journal. Vol. iv. nos. 11 & 12.

Literary Gazette for January and February.

Philadelphia Academy of Natural Sciences, Proceedings. Vol. v. no. 5.

———. Journal. New Series, vol. ii. part 1.

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

Royal Institution, Proceedings. Nos. 1 & 2.

Royal Society. Philosophical Transactions, Part 2, 1849; and Parts 1 & 2, 1850. Proceedings, nos. 73, 74 & 75; and Lists for 1849 and 1850.

Scarborough Philosophical Society. 19th Report, 1850.

Shropshire and N. Wales Natural History Society. Report for 1850.

Zoological Society, Transactions. Vol. iv. part 1.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in italics.

Beke, Chas. T., Ph.D. Reasons for Returning the Gold Medal of the Geographical Society of France.

Burmeister, Dr. Hermann. Die Labyrinthodonten aus dem Saarbrücker Steinkohlengebirge, zoologisch geschildert. Abth. 3.

Carter, H. J. Geological Observations on the Igneous Rocks of Maskat, &c.

Catullo, Sig. A. Four Plates of Ammonites, additional to those published with the "Cenni sopra il Systema Cretaceo delle Alpi Venete," &c., and Four Plates of Tertiary and Palæozoic Corals.

D'Archiac, A. Histoire des Progrès de la Géologie de 1834 à 1849. Tome iii.

Dechen, H. von. Ueber die Schichten im Liegenden des Steinkohlengebirges an der Ruhr.

De la Beche, Sir H. T. The Geological Observer.

Faraday, Michael. Experimental Researches in Electricity. Series 24–27.

Geinitz, H. B. Das Quadersandsteingebirge oder Kreidegebirge in Deutschland. *From Messrs. Williams and Norgate.*

General Board of Health. Report on the Supply of Water to the Metropolis. Appendices, nos. 1–4. *From the Rt. Hon. the Earl of Enniskillen, F.G.S.*

Jäger, Dr. Georg. Ueber die Fossilen Säugethiere Würtembergs.

Johnston, A. K. Historical Notice of the Progress of the Ordnance Survey in Scotland.

Leonhard, Dr. Gustav. Geognostische Uebersichtskarte von Spanien von Ezquerra del Bayo.

Logan, W. E. Geological Survey of Canada. Report of Progress for the years 1848–49 and 1849–50.

Lyell, Sir Charles. A Manual of Elementary Geology.

Mantell, G. A., LL.D. On the Remains of Man, and Works of Art imbedded in Rocks and Strata.

————. Supplement to the Geology of the Isle of Wight.

Observations on Days of Unusual Magnetic Disturbance, made at the British Colonial Magnetic Observatories. Vol. i. parts 1 & 2. *From Lieut.-Col. Sabine, by direction of the British Government.*

Owen, Prof. On the Dinornis (Part 4).

Pictet, F. J. Description de quelques Poissons Fossiles du Mont Lihan.

Puggaard, C. Möens Geologie Populært Fremstillet.

————. View of Möens Klint, with explanatory Section.

Rennie, George. Report on the Supply of Water to be obtained from the district of Bagshot.

Ricci, Procaccini. Viaggi ai Vulcani spenti d' Italia nello Stato Romano verso il Mediterraneo. 2 vols. *From Rev. John Simpkinson.*

Rowlandson, Mr. Report on the Schemes of the Hon. Mr. Napier and the General Board of Health, for a New Supply of Water to the Metropolis.

Santi, Giorgio. Viaggio al Montamiata. 3 vols. *From Rev. John Simpkinson.*

Sömmerring, S. T. von. Ueber die Lacerta gigantea der Vorwelt. *From Rev. John Simpkinson.*

Spence, W. Letter to the Entomological Society, July 20th, 1850, with a Print of the late Rev. William Kirby.

Turner, H. N., Jun. On the Evidences of Affinity afforded by the Skull in the Ungulate Mammalia.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

MAY 14, 1851.

Samuel J. Mackie, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* DISTRIBUTION *of the* FLINT DRIFT *of the* SOUTH-EAST *of* ENGLAND, *on the* FLANKS *of the* WEALD, *and over the* SURFACE *of the* SOUTH *and* NORTH DOWNS. By Sir RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. G.S. &c.

[This paper will appear in the next Part.]

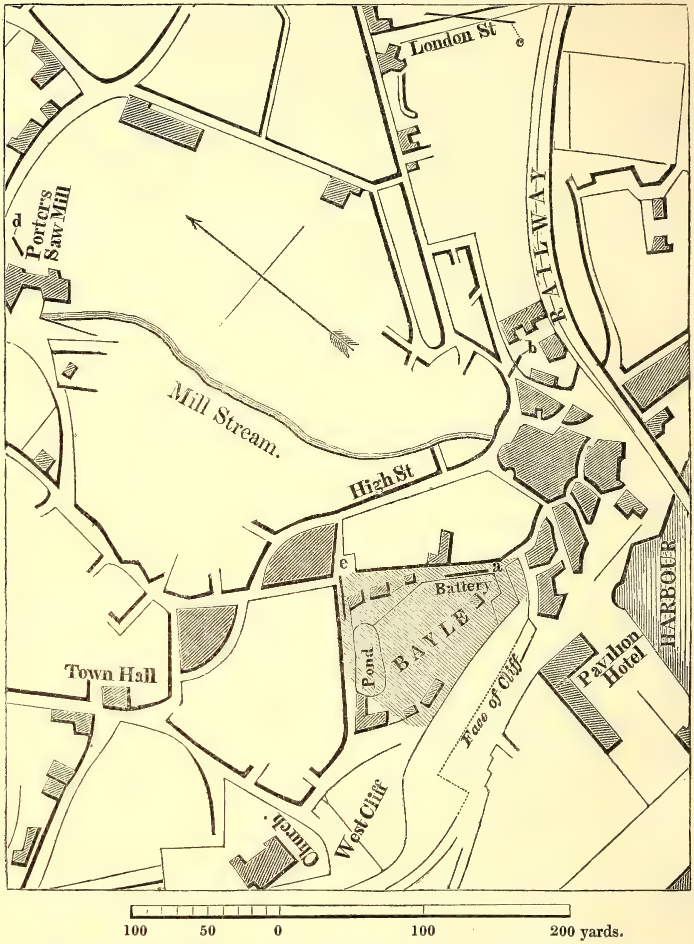
2. *On a* DEPOSIT *at* FOLKESTONE *containing* BONES *of* MAMMALIA. By SAMUEL J. MACKIE, Esq., F.G.S.

THE high ground of the Lower Greensand at Folkestone forms a gently inclined plain, stretching inland as far as the hills of the Chalk-escarpment. Between this plain, which constitutes the West Cliff, and the East Cliff or Copt Point, there is a valley*, from 40 to 90 feet deep, in which a considerable part of the Old Town is built, extending in a curving direction through the village of Ford (at which place it is crossed by the viaduct of the South Eastern Railway) towards

* See View of Folkestone in Dr. Fitton's Section of the Coast, Trans. Geol. Soc. N. S. vol. iv. Pl. 8.

the escarpment of the hills, which skirt, as it were, the sandstone-plain of the West Cliff.

Fig. 1.—*Plan of a part of the Town of Folkestone.*



a. Section of the Bone-bed, &c., exposed at Mr. Craxford's house, on the Bayle (see fig. 3).
b. The lowest point at which the Brick-earth occurs.
c. Section of the Brick-earth and angular-flint-gravel, exposed at London Street (see fig. 4).
d. Section of the Brick-earth at Porter's Saw Mill.
e. Section of the Bone-bed at the Town Sewer on the Bayle.
The shaded portion of the Bayle indicates the extent of the Bone-bed.

At the south-eastern corner of this plain (at an elevation of 110 feet above low-water-mark) on the top of the West Cliff, under the Battery, and lying immediately on the upper beds of the Lower Greensand, which are of loose disintegrated sand, is a deposit, from 1 to 9 feet thick, consisting of flint pebbles and boulders;

the former are small and round, the latter generally angular and slightly worn. With these are associated fragments of compact ferruginous sandstone, and the whole is intermixed with loamy sand and calcareous gritty marl. The marl, for the most part, forms the upper portion of the bed, which extends on the face of the cliff for a distance of 320 feet. The bed may be here seen following the irregularities of the uneven surface of the rock on which it rests, and distinctly displaying the variations in its thickness (see fig. 2).

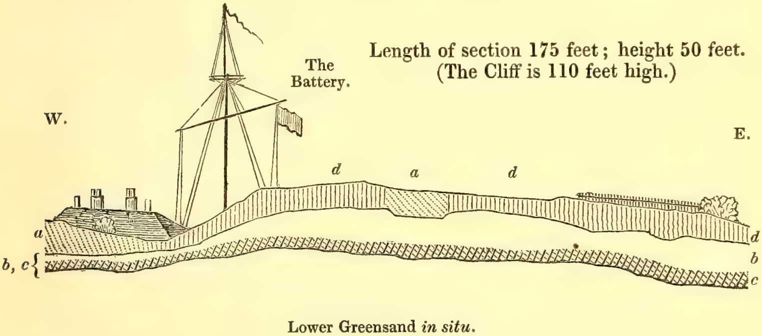
It contains, generally in the lower part, a considerable number of the remains of Elephant, Ox, Stag, Hyæna, Hippopotamus, Irish Deer, &c., and, in the marly portion, numerous specimens of two or three species of Helix* : no fluviatile molluscs have hitherto been observed.

The Bones and Shells, however, are found both in the gravel and in the calcareous marl above it.

This bed appears to be cut off by the valley, previously referred to, towards which it thins out altogether; and no traces of organic remains have been found on the east side of the town. On the west it thins off beneath a bed of dark brown clay, much resembling the superficial brick-earth that is found on the surface of the plain, and at many places in the neighbouring country.

The shaded portion, comprising the Bayle and the Battery, on the accompanying plan (fig. 1) shows the extent of the deposit, as above described. But its distribution is much more extensive, if we regard this bed as being intimately connected with the flint and iron-sandstone Drift which covers the tops of the Chalk-hills, and with the Brick-clay found on the Gault and Greensand plain on which this Bone-bed lies.

Fig. 2.—*Section of a part of the West Cliff, Folkestone.*



a. Brick-earth.
b. Calcareous marl with Snail-shells.................. } Bone Bed.
c. Flint-gravel and ferruginous grit, with a few Gault nodules. Contains bones of Mammalia. }
d. Vegetable mould.

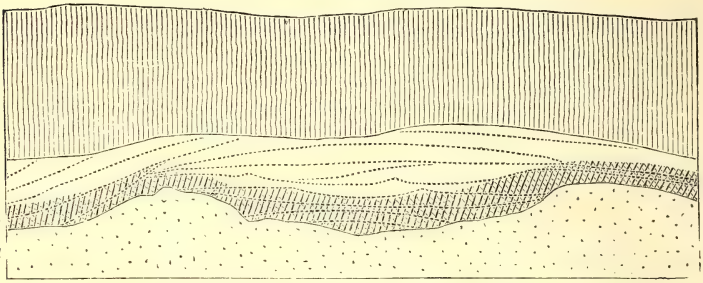
The Section, fig. 2, represents the "Bone Bed" as seen on the face of the West Cliff (see Plan); and the Section, fig. 3, taken at a right

* First observed by Mr. J. Morris, F.G.S.

angle to the foregoing, was exposed in the excavation for Mr. Craxford's House. (See Plan, fig. 1, *a*.)

Fig. 3.—*Part of the Section exposed in digging the foundation of Mr. Craxford's House.*

Length 35 feet; height 14 feet. The base of the Section is on the Road, 105 feet above low-water mark.



a. Black earth, containing bones of *Canis lupus* and *Sus scrofa*, fragments of ancient pottery and iron arms? 6 feet.
b. Calcareous sandy marl.
c. Lower portion of the same, with flint and ferruginous sandstone boulders and pebbles, both angular and round. } Marked with wavy lines of stratification, and containing Bones of Mammalia. } Bone Bed. 1—5 feet.
d. Lower Greensand *in situ.*

The whole of the "Bone Bed" appears to have been subjected to the action of water, as the flints and grit-boulders, although angular, are partially worn, and the chalk-nodules and softer pebbles are completely rounded; the stratification, also, of the marl, sand, and boulders follows the irregularities of the Lower Greensand on which they rest.

There is no evidence that this deposit was of marine origin, marine remains* not having been found in it; on the other hand, the bones of Mammals and the Snail-shells, with which it abounds, would indicate its fluviatile or lacustrine origin.

The presence of a breccia of chalk-flints, if so it may be termed, at this spot is somewhat singular, no flinty chalk occurring at a less distance than six miles to the north or east, and the grey chalk rising between that member of the Cretaceous group and the "Bone-deposit," and forming the highest ground of the whole district.

The finer portions of calcareous marl and loam would, to a great extent, appear to have been derived from the waste of the Chalk, the marl possessing all the usual mineral characters of such sediments; and I have also found the little *Terebratula rigida*, so characteristic of the Chalk, in the sandy loam. A microscopic investigation carries this view still further, and favours also the idea of the probable identity of age and origin of the Bone-bed with the Brick-clay and Drift; the calcareous marl of the first-named deposit abounding with *Foraminifera* and other microscopic organisms, many forms of which are

* Excepting foraminifera, &c., of the Chalk, obviously derived from detrital action.

immediately recognized as the ordinary species of the Chalk; the same also being the case with the Brick-earth and the clayey portions of the Drift.

Mr. Rupert Jones, who at my request examined my prepared "slides," as well as a small quantity of the marl and brick-earth, has kindly furnished me with the following lists.

From the Calcareous Marl of the Bone-bed:—

Verneuilina tricarinata.
Textularia globosa, trochus, and others.
Polymorphina?
Bulimina variabilis and another.
Rosalina.
Globigerina cretacea.
Cristellaria rotulata and another.
Rotalia globosa.
Nodosaria.
Single cells, ovoidal and globular, = Oolinæ? and portions of other Foraminifera.
Prismatic fragments of Inoceramus.
Fragments of Echinodermata.
Ossicles of Apiocrinites.
Valves of Cytherella ovata and C. truncata.
—— Bairdia subdeltoidea and B. Harrisiana.
—— Cythere Hilseana (? derived from Chalk-marl).

From the Brick-earth of Gambrill's Pit, ½ mile N.W. of the Bayle:—

Rotaliæ, Rosalinæ, and single ovoidal cells.
Helix.
Pupa.

In the Drift of Folkestone Hill, Chalk-organisms are plentiful.

Two excavations on the West Cliff, one for Mr. Craxford's House (see Plan, fig. 1, *a*), the other for the Town-sewer on the Bayle (see Plan, fig. 1, *e*), have afforded me all my present collection of bones and shells from this deposit.

List of the Organic Remains from the "Bone Bed."

Bones and Horns.

Elephas primigenius.
Hippopotamus major.
Bos primigenius.
—— urus.
—— longifrons.
Cervus elephas.
Megaceros Hibernicus.
Equus.
Hyæna spelæa.

Shells.

Helix nemoralis.
—— concinna.

Prof. Owen kindly inspected and determined a large collection of the bones exhibited to the Society. The list comprises also some other specimens determined by H. Turner, jun., Esq.

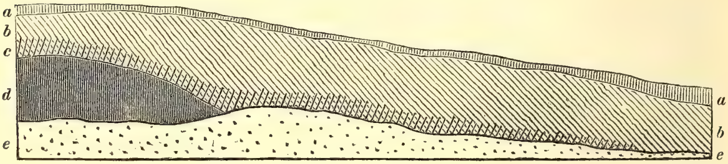
The Drift and Brick-earth.—The probable relation of the mammaliferous deposit above-described with the Drift was suggested to me by Sir Roderick I. Murchison,—the occurrence of angular flints being singularly characteristic in both cases, to which fact the following example, fig. 4, one out of the many that could be given, has especial reference.

The sections of Drift and Brick-earth everywhere in the neighbourhood and at every elevation from 40 to 570 feet above the sea present this peculiar feature.

I would briefly observe that at Mr. Gambrill's Brick-Pit, at the back of Sandfield Villas, on the west side of the valley and inland of the Bone-bed, there is a thickness of 15 feet of clay, through which run, at short distances apart, thin layers of small pieces of flint and ferruginous grit, termed "roach" by the workmen, and from the lowest seams of which I have a fragment of bone (Horse), found by one of the labourers in digging the brick-earth.

Fig. 4.—*Section of the Brick-earth at London Street.*

Length 80 feet; height 17 feet.



a. Alluvium.
b. Brick earth. }
c. Angular flint drift. }
d. Gault *in situ.*
e. Lower Greensand *in situ.*

The lower portion of this clay contains abundantly land- and fresh-water-shells, namely:—

Helix concinna.
Pupa.
Succinea oblonga.

At a distance of about 70 feet to the north of this pit, the Lower Greensand is found (at the side of the road leading to Ford) only 4 feet from the surface,—showing the face of the greensand against which the brick-earth there abuts to be very steep.

I may add that I have the antler of a Deer from the New Reservoir of the Water-works at the Cherry Garden, N.N.W. of the Bayle (at an elevation of 232 feet), the core of a horn of *Bos urus* from an excavation at the corner of Darlington Place, $\frac{1}{4}$ mile N. of the Town Hall, near the Viaduct (elevation 138 feet), and that a large fragment of a Cetacean bone is in the possession of William Bateman, jun., Esq., of this town, who obtained it of one of the workmen employed at Porter's Saw Mill (elevation 50 feet), see Plan, fig. 1, *d*; but, not having been present at any of these excavations, I cannot state the mineral characters of the beds in which they were found; in the last two cases I believe them to be the ordinary brick-earth.

I have digressed thus far from my proper subject, thinking the above facts, with my discovery of the microscopic organisms of the Chalk in the Bone-bed, Drift, and Brick-clay, would indicate some relation between these three deposits, and serve to determine in some measure the probable epoch of the formation of the Bed to which this paper refers.

May 28, 1851.

The following communications were read:—

1. *On the* Geological Structure *of the* Mountain Range *of* Western Persia. By William Kennett Loftus, Esq., F.G.S.

[In a letter to J. S. Bowerbank, Esq., F.G.S.]

Few mountain-regions, perhaps, exhibit such uniformity of structure as the Tagros Range. Here the direction of the great chains is generally from south-east to north-west, the Tagros consisting entirely of a succession of limestone saddles which extend in parallel lines for many miles, the troughs between being filled with much-contorted beds of gypsum and variegated marls. No fossils whatever are found in these gypsum-beds, but in the limestone are sparingly scattered *Ostrææ, Buccina, Nummulites,* and *Echini,* of tertiary forms, as far as I am able to judge; but the rock is so crystalline that it is impossible to procure a single specimen exhibiting any decided character. The beds below the limestone are red chert-conglomerates, sandstones, and blue shales. At Khorramabad the Yaftah Kuh rises abruptly from the plain and consists of grey cherty limestone, abounding with thick beds of flint, which I am inclined to believe belong to the Chalk-formation, although fossils are entirely wanting. On the eastern side of the Tagros, as far as the base of the Kuh Elwend, the serrated peaks, which rise from these high table-lands and form picturesque, although by no means magnificent scenery, are of hard, compact, and crystalline blue limestone, containing a few of the same fossils as before. This rests unconformably on beds of yellow slaty limestone, which again rest upon clay-slates. At Kuh Elwend these clay-slates are raised into a vertical position by felspathic granite, which constitutes the axis of the chain. Beds of mica-schist are also found in conjunction with the clay-slates. From Hamadan to Isfahan the order is as follows (descending):—1. blue limestone, much contorted; 2. yellow calcareous slates; and 3. clay-slates.

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2. *On the* Remains *of* Fish *in the* Silurian Rocks *of* Great Britain. By John William Salter, Esq., F.G.S.

A belief in the existence of Fish-remains in the older members of the Silurian system, as well as in newer deposits of that period, has of late years grown prevalent in this country, and has attracted considerable attention. The statements put forward in the session of 1846–7 by two of our leading geologists as to these remains having positively been found in these lower strata, by Professor Sedgwick in South Wales, and by the collectors of the Geological Survey in North Wales, added to the fact of Professor M'Coy having previously described a fish-scale from the Silurian rocks of Waterford, appear to give a sufficient basis for this opinion. It has now assumed a definite shape, and furnished the materials for a tabular view of the successive appearances of fish, given in Mr. Hugh Miller's work, entitled "Foot-prints of the Creator."

As the well-deserved reputation of this eloquent author will give a wide currency to his book, it is desirable to explain the nature of the evidence on which these statements rest, and I am the more called on to do so, since for two of the instances above-mentioned, viz. with regard to North and South Wales, I am indirectly responsible.

During the summer of 1846 I was engaged in examining, for the Geological Survey, the fossils along the Silurian frontier in South Wales, and I had the pleasure of meeting Prof. Sedgwick at Llandeilo, and visiting several of the localities with him. During one of his excursions he obtained a slab of the Llandeilo limestone, upon which there lay a compressed and tapering fossil, longitudinally ribbed, and bearing so much general resemblance to the defensive fin-bone called *Onchus*, that I at once named it so; nor were we at that time disposed to question its probability, since we were both labouring under the mistaken impression that these flags occupied a higher position than had been assigned them, and that they were but little below the parallel of the Wenlock Shale. And in the winter of that year Prof. Sedgwick advocated this view in a paper read before the Society, and announced the discovery of "defences of fishes" in the Upper Llandeilo Flags of South Wales.

During the same year the Geological Surveyors were at Bala, in North Wales, examining the localities which had been noticed by Prof. Sedgwick in his papers on that country, and making rough catalogues on the spot of all the fossils met with. Amongst them occurred a fragment, curved like some *Onchi*, and, like the Llandeilo one before noticed, striated lengthwise. This fragment also was entered in our rough catalogues as a fish-defence!—the analogy of course being more readily perceived from the fact of having only a few weeks before seen what was believed to be an Ichthyolite from beds of the same age. This specimen also, like the former one, was only cursorily examined. It was, however, mentioned in conversation to Sir Roderick Murchison, and, in a Memoir on the Classification of the older Rocks, read before the Society January 1847, he used it as an argument for the union of the fossiliferous rocks of North Wales with the Lower Silurian*,—a point now perfectly established on other grounds.

But, on examining in London the specimens collected at Bala, I found that the supposed fish-spine was in reality half the rostral shield of a Trilobite common there, the *Illænus Davisii*, and that its resemblance to an *Onchus* was due merely to its being broken in half and obscured by stone.

The Bala fish being thus disposed of, the probability of the Llandeilo one being equally spurious became manifest; and I was not at all surprised to find it described last year by Prof. M'Coy† as a new genus of Asteroid Zoophyte, probably allied to the "Glass-plant," and under the name *Pyritonema fasciculus*. As Prof. M'Coy has

* Quart. Journ. Geol. Soc. vol. iii. p. 176.

† Ann. & Mag. N. H. Ser. 2. vol. vi. p. 273.

fully described and figured it in the 1st part of the "Catalogue of the Woodwardian Museum," just published, it is unnecessary to speak more of it here, except that I have examined it at Cambridge, and quite agree with him in rejecting it from the class of Fishes.

That the existence of fish in these early deposits has gained general credence, is evidenced not alone by the work of Mr. Miller, cited above. Alcide D'Orbigny, in his 'Cours Élémentaire de Paléontologie,' published in 1849, refers to one species of the *Cestracionidæ* in the *étage Silurien,* which in his scheme includes only the Lower Silurian rocks of English geologists; and in his table of the distribution of families, the *Cestracionidæ* make their first appearance in the *Silurien inférieur,* and continue, although in smaller numbers, through the *étage Murchisonien,* or Upper Silurian. He has since repeated this table in the 'Annales des Sciences' for 1850.

As Mr. Miller's work also gives currency to the idea long held by Prof. Sedgwick, as well as by other geologists and myself, viz. that the Bala limestones lie below the rocks of Plynlimmon, and these again beneath the Llandeilo flags of South Wales, it may be well here to refer to the paper by Prof. Ramsay, in vol. iv. of the Quarterly Journal, p. 294, in which, as the result of the observations of the Survey, the contemporaneity of all these beds is directly stated or implied. Although the Bala limestone itself cannot be traced into South Wales, there is a peculiar and very constant band of sandstone and conglomerate, occurring at several hundred feet above it, which extends down continuously into Radnorshire, occupies many tracts in the country about Plynlimmon and the central parts of Wales, and appears in great force in Caermarthenshire, at about the same elevation above the Llandeilo limestone as it does at Bala. So that, if not exactly the same calcareous bed (and the perfect identity of their fossil contents would lead us to believe they are the same), these two bands of limestone lie on the same geological horizon, and in like manner the rocks of Central Wales are proved to be of equal age, although destitute of the calcareous beds, and almost void of fossils.

We may now, therefore, safely say, that in the great Lower Silurian series there has been no evidence published which justifies us in assigning so early a date to the class of Fishes.

As yet no remains of this order have been quoted from the Caradoc Sandstone, for the scales of a fish, described by Prof. M'Coy in 1846 as from the "Caradoc Sandstone" of Wexford, belong to the Llandeilo flags, and to nearly the parallel of the Llandeilo and Bala limestones. And his opinion, expressed in a letter to me, is at present that these so-called scales are plates of a peculiar Cystidean. In this view I perfectly agree; they are very like some species of this tribe which occur plentifully in South Wales, and he had himself, when describing the fossil*, noticed their striking analogy with these plates, although there were still some peculiarities which induced him to refer them provisionally to Fish.

* Synopsis of the Silurian Fossils of Ireland, published under the auspices of R. Griffith, Esq., of Dublin.

Fish have been quoted from the Wenlock shale of the Malverns in the paper by Sir Roderick I. Murchison referred to above. This was on the authority of Prof. John Phillips, who at that time thought he had found some minute remains of the kind, but now distinctly states that he must not be considered as authority for fish-remains in any stratum older than the upper beds of the Aymestry limestone, in which he has certainly found them, as stated in the second volume of the Memoirs of the Geological Survey, Part 1. p. 226.

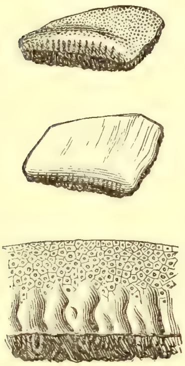
We must now turn to the next bed in succession, and to the only authenticated instance known in Britain of Fish occurring in the Wenlock limestone. I refer to the notice, first published in the Edinburgh Review for July 1846, of a true Cestraciont palate found at Longhope, Gloucestershire, by the Rev. P. B. Brodie. Desirous of following up this investigation, I have communicated with that gentleman on the subject, and he has kindly given me the fullest information, and allowed a drawing to be taken from this valuable specimen.

Tooth of Cestraciont Fish, found in Longhope Quarry.

a

b

c



a. Edge view.
b. Outline.
c. Part of the surface and edge magnified.

His account of the discovery is, that a friend of his, interested in the collection of organic remains, but not a practical geologist, found two of these bones lying together mixed with the ordinary shells and corals of the locality, in the Longhope quarry. Mr. Brodie visited the spot with him, and ascertained the exact locality; he then sent the specimen, here figured, to Sir P. Egerton, who at once pronounced it a Cestraciont fish, and under that title it was mentioned by the writer in the Edinburgh Review. But unfortunately, as I think, for its authenticity, it was found lying loose among the debris of the quarry, not imbedded in the shale; and it has such a suspicious resemblance to certain fish-palates which occur in the Mountain Limestone quarries of Mitchel Dean, not four miles distant, that I confess I have the greatest doubts as to its origin. It is not at all unlikely that quarrymen of Mitchel Dean, who pick up these showy fossils, might be working in the Longhope quarries, and drop them from their pockets. The specimen has been since re-examined by Sir P. Egerton, and, as it appears to him to be an undescribed species of the genus *Cochliodus*, the question must still remain open.

With regard to the existence of Fishes in the Uppermost Silurian strata there can of course be no question. Those described and figured by Sir R. I. Murchison from the Bone-bed of the Upper Ludlow rocks prove this point; and also that these fishes were of the Placoid order. Prof. Phillips, in the second volume of the Memoirs of the Geological Survey, has also noticed fresh localities where this bone-bed contains remains of teeth and scales; and has detected such fragments in the Malvern region down as far as the upper surface of the *Aymestry rock.* But I have his authority for saying, that he has never found any traces that he could rely on below that parallel.

And in these uppermost strata they not only occur in Britain, but in other places. M. Barrande is about to publish large bony fragments 6 or 8 inches long, obtained from the top of the Silurian system in Bohemia. And the American geologists have figured and described large defensive spines collected in their Onondago and Corniferous Limestones, and some are mentioned even from the Oriskany Sandstone. M. de Verneuil, it is true, would regard this last-named stratum as the base of the Devonian system in America; but whether this interpretation be accepted, or that which seems most generally the opinion in America, that these rocks belong to the Upper Silurian, they do not warrant our believing that Fish-remains occur there so far down as the parallel of our Wenlock limestone.

But while thus endeavouring to show that there has hitherto been no evidence published on which the existence of Fishes in the Lower Silurian can be established, I have a new and very interesting fact to communicate which makes their occurrence at this epoch a matter of great probability. At the same time that the spurious fish-defence was collected by the Geological Survey in North Wales, certain rounded black substances, not above half an inch diameter, were found with it, which suggested the idea of *coprolites*. These have been since analysed in our laboratory by Dr. Playfair, who found them to contain the very large proportion of above thirty per cent. of phosphate of lime. This, then, would at once decide the question, were it not for the occurrence, in more recent strata, of phosphatic nodules of doubtful origin, since no substance is known at present which could yield so large a quantity of this mineral except bone, and that of vertebrate animals; while its occurrence in the form of coprolite would point at least to Fish or some higher animal as its origin. But it was of course necessary to ascertain whether the matrix was impregnated with the phosphate or not, since the discovery by Dr. Daubeny of large veins of this substance in the older slate-rocks of Spain is so well known. Dr. Playfair has therefore analysed the limestone of Rhiwlas* near Bala, in which these black bodies were found; but although the rock is so charged with organic remains as to yield two per cent. of animal matter, not a trace of the phosphate presented itself. The conclusion, therefore, seems almost inevitable, that animals of a high organization, and most probably, therefore, Fish, existed during the deposition of the Llandeilo flags.

The point of earliest appearance of any of the great divisions of the animal kingdom is of course a subject of deep interest to the geologist, and even more so to the naturalist. That there has been a gradual development of the higher forms of life as we ascend in the series, at

* I should like to call the attention of geologists and tourists to this remarkably rich locality, where certainly the rarer fossils of the Lower Silurian rock are to be found more plentifully than in any other locality. The entire pelvis of some large Encrinites would reward careful work, and great numbers of Trilobites, spiral shells, and Orthoceratites are to be met with. Cystideans also of six or eight species abound there.

least in the way of addition, seems scarcely a matter of doubt. But the exact point at which each group began is the point to be ascertained; and, although the progress of research has carried back many groups into the older strata which were formerly believed to have had a shorter existence, there seems hardly sufficient reason for inferring that this may be indefinitely extended to all groups, and throughout all the oldest rocks.

This short notice is intended to place upon a more correct basis the opinion, which still seems a highly probable one, that Fishes existed in the British Isles along with the earliest fauna, which comprehended a variety of marine forms.

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3. *On the Elevatory Forces that raised the* Malvern Hills. By H. E. Strickland, Esq., F.G.S.

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

June 11, 1851.

The following communications were read:—

1. Section *and* Analysis *of* Permian Beds *at* Astley, Lancashire. By G. Wareing Ormerod, Esq., M.A., F.G.S.

The Permian beds, of which the Analysis and Section are here given, are situated in the estate of Colonel Ross, in Astley, by the eastern edge of the Township of Bedford, in the Parish of Leigh, in South Lancashire.

These beds were formerly worked very extensively as a hydraulic lime at the place where these borings were taken, and for this purpose they are still worked in the neighbourhood. A general description of these beds, as existing in South Lancashire, is given by Mr. Binney in the 'Transactions of the Manchester Geological Society,' vol. i. pages 43 to 46 and 54 to 56, and also in his paper "On the relation of the New Red Sandstone to the Carboniferous Strata in Lancashire and Cheshire," in the Quarterly Journal of the Geological Society, vol. ii. pages 22 and 23.

The fossil remains here found are the same as those described in the first-mentioned paper, at pages 54 to 56, and consist of the *Axinus*, *Avicula*, and other Magnesian Limestone fossils. The "Four-foot Coal," the highest coal worked in this district, and the highest workable coal of the middle division of the Lancashire coal-field, is worked under the places where the following bore-holes were made. The bore-hole, marked B in the following sections, is situated about 600 yards to the west of a coal-shaft, being nearly on the strike of the measures from the shaft. In this shaft, as I am informed by Mr. Darlington, the Coal-Lessee, the thickness of the shales and thin seams of coal, overlying the "Four-foot coal," is 351 feet. The Magnesian or Permian beds overlie the Coal, and are at the shaft about

6 feet in thickness. These are overlaid by 15 feet of clay and surface-soil, making the total depth of the shaft 126 yards. Mr. Darlington states that the amount and direction of dip at the shaft are the same in the Coal-measures and the Permian beds, being about 10° S.S.E. This pit is the most easterly point at which the Magnesian Limestone has been found in this district. At the place where the bore-holes were made the beds are not exposed to view, so that the dip at that place cannot be given. The surface of the land at the central bore-hole "B," is about 3 feet below the natural surface at the pit-mouth. The borings at "B" show surface-soil and clay 17 feet 5 inches, and Magnesian beds 10 feet, showing an increase of thickness over that at the pit.

In the most northerly boring, "A," there are five beds of limestone, varying in thickness from 1 inch to 3¾ inches, and amounting to 11¼ inches. The intervening beds of Red-earth vary from ¾ of an inch to 5½ inches and amount to 8½ inches, making the thickness of the Permian beds, without including the Red-earth under the lowest limestone, 1 foot 7¾ inches. The total depth of this boring is 21 feet 8½ inches.

In the central boring, "B," there are twenty-eight beds of limestone, varying in thickness from 1 inch to 8¾ inches, and amounting to 5 feet 6¾ inches. The intervening beds of Red-earth vary from ¼ of an inch to 6¾ inches, and amount to 4 feet 6 inches, making the thickness of the Permian beds, without including the Red-earth under the lowest limestone, 10 feet ¾ inch. The total depth of this boring is 28 feet 8½ inches.

In the most southerly boring, "C," there are twenty-five beds of limestone, varying in thickness from ½ an inch to 8¾ inches, and amounting to 5 feet 6 inches. The intervening beds of Red-earth vary from ½ inch to 4½ inches, and amount to 4 feet ½ inch, making the thickness of the Permian beds, without including the Red-earth under the lowest limestone, 9 feet 6½ inches. The total depth of this boring is 69 feet 8 inches.

The average thickness of the beds of limestone is 2½ inches, and that of the intervening Red beds 2 inches.

Mr. Darlington informs me that on the deep of his workings the Magnesian Limestone is covered by the Red Sandstone, having the same dip as the Magnesian Limestone.

The following is an analysis of the unburnt limestone and intervening beds at the borings above mentioned:—

	Clay Beds.		Limestone Beds.	
Insoluble in Acids.........		68·0		16·6
Soluble Silica	0·33		1·0	
Sesquioxide of Iron	7·0		4·66	
Alumina.....	1·33		2·66	
Carbonate of Lime	18·0		63·4	
Carbonate of Magnesia...	5·0		10·33	
Soda	0·34		Soda & Potash 0·66	
Loss	......		0·69	
	——	32·0	——	83·4
		100·0		100·0

The following is an analysis of the same limestone-beds (after being burnt) from a neighbouring estate in the Township of Bedford:—

Silicic Acid	16·0
Peroxide of Iron	6·0
Alumina	2·75
Lime	68·25
Magnesia	6·50
Chloride of Sodium and Oxide of Manganese	0·50
	100·0

The above were made by Mr. F. Crace Calvert, Honorary Professor of Chemistry at the Royal Manchester Institution.

Comparison of three Borings made at Astley.

	A.		B.		C.	
	ft.	in.	ft.	in.	ft.	in.
Surface or soil	1	3	1	0	1	5
Clay mixed with sand	1	5	3	6	5	2
Red clay	4	0	1	0	0	1
Loamy clay with sand	......		0	3	0	4
Red clay	6	11	7	7	6	6
Clay with white specks	1	10	0	8	0	2
Rock (first false bond-stone)	......		......		0	4
Strong red earth	......		......		3	9
Stone	......		......		0	1½
Strong red earth	......		......		4	1½
Red shale	......		......		2	6
Gingerbread or red metal	......		......		1	0
Very strong red earth	......		......		1	3
Strong red shaly rock	......		......		0	7
Very strong red earth or metal	......		......		10	6½
Strong red rock	......		......		1	0
Strong red metal	......		......		0	7½
Hard brown rock	......		......		0	4
Soft red earth	......		......		0	1½
Very hard strong brown rock	......		......		1	6
Red earth	......		......		0	7¼
Rock (second false bond)	......		......		0	3¼
Red earth	......		......		2	4
False stone, "Gunbrick"	......		......		0	1½
Red earth	......		......		2	4½
False stone	......		......		0	2
Red earth	......		......		0	11½
False stone	......		......		0	2
Red earth	......		......		0	7
False stone	......		......		0	1
Red earth	......		......		0	1
Rock (third false bond)	......		0	3¼	0	4
Red earth with white specks	......		1	8¾	1	10
Strong brown stone bond	......		1	4¾	0	2½
Red earth with white specks	......		0	0¼	0	8
Depth from surface to main bond, or No. 1 bed of limestone	......		17	5	52	9
No. 1 limestone	......		0	8¾	0	8¾
Red earth	......		0	3½	0	3½
No. 2 limestone	......		0	4¼	0	5½

	A.		B.		C.	
	ft.	in.	ft.	in.	ft.	in.
Red earth	......		0	2	0	4½
No. 3 limestone	......		0	1	0	1½
Red earth	......		0	4	0	1
No. 4 limestone	......		0	2¼	0	1½
Red earth	......		0	4	0	2
No. 5 limestone	......		0	1½	0	3¾
Red earth	......		0	6¾	0	6
No. 6 limestone	......		0	1	0	3½
Red earth	......		0	1	0	0½
No. 7 limestone	......		0	5½	0	1¾
Red earth	......		0	0½	0	1
No. 8 limestone	......		0	2¾	0	2¾
Red earth	......		0	1¾	0	0¾
No. 9 limestone	......		0	2½	0	1½
Red earth	......		0	0¾	0	0½
No. 10 limestone	......		0	0¾	0	2½
Red earth	......		0	1½	0	1
No. 11 limestone	......		0	1½	0	4¾
Red earth	......		0	0¼	0	3
No. 12 limestone	......		0	2	0	3¾
Red earth	......		0	3¼	0	1
No. 13 limestone	......		0	2¼	0	2
Red earth	......		0	0½	0	4
No. 14 limestone	......		0	3¼	0	2¼
Red earth	......		0	6½	0	4
No. 15 limestone	......		0	1½	0	0½
Red earth	......		0	1	0	0¾
No. 16 limestone	......		0	1	0	1
Red earth	......		0	2	0	0½
No. 17 limestone	......		0	2	0	4
Red earth	......		0	0¾	0	1
No. 18 limestone	......		0	1½	0	4
Red earth	......		0	0¾	0	2
No. 19 limestone	......		0	2¾	0	3¼
From surface	15	5				
Red earth	......		0	1½	0	3
No. 20 limestone	0	1¾	0	1	0	1½
Red earth	0	2¼	0	0½	0	1
No. 21 limestone	0	2½	0	3¼	0	2¼
Red earth	0	0½	0	1	0	0¼
No. 22 limestone	0	3½	0	2¼	0	1
Red earth	0	0½	0	0¼	0	1
No. 23 limestone	0	1	0	1½	0	0½
Red earth	0	5¼	0	3	0	6
No. 24 limestone	0	2½	0	2	0	2¾
Red earth with white specks	......		0	0¼	3	4¼
No. 25 limestone	......		0	1	0	2¾
Red earth, no rock brought up by borer	4	7¾	......		3	9¼
Red earth	......		0	0¼	......	
No. 26 limestone	......		0	1½	......	
Red earth	......		0	2½	......	
No. 27 limestone	......		0	2¾	......	
Red earth	......		0	4	......	
No. 28 limestone	......		0	3¼	......	
Red earth	......		1	3	......	
	21	8½	28	8½	69	8

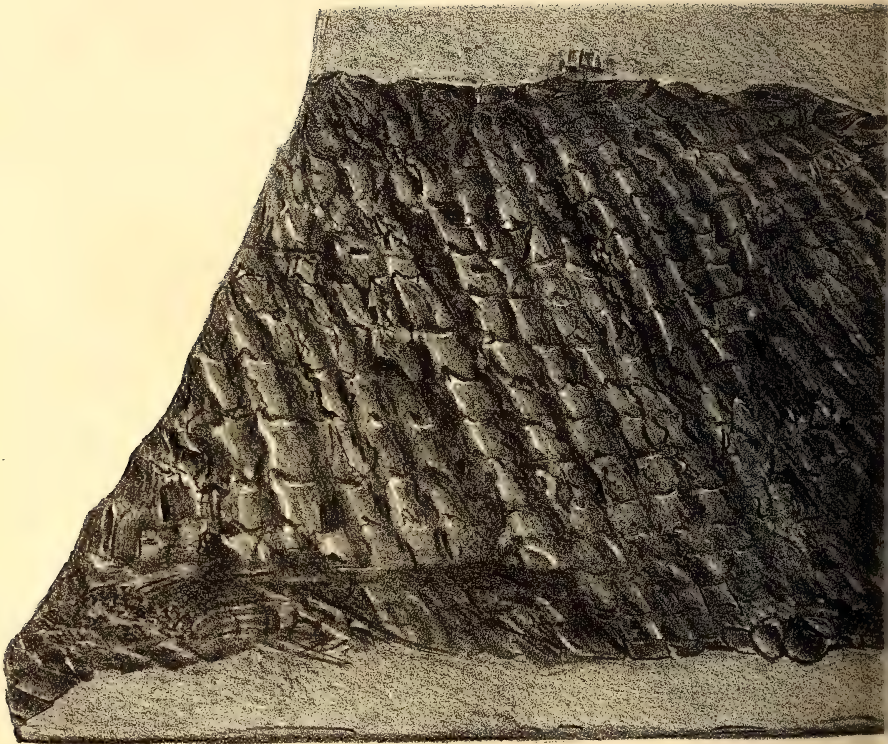
2. *On a* Fossil Fish *from the* Table-land *of the* Deccan, *in the Peninsula of* India. By Colonel Sykes, F.R.S., G.S. *With a* Description *of the Specimens.* By Sir P. de M. G. Egerton, F.R.S., G.S.

[Pl. XV.]

General Fraser, the British Minister at the Court of the Nizam at Hyderabad, in a letter to me dated the 31st July 1850, mentioned his having transmitted some specimens of fossil fish, with impressions of leaves, in a matrix which Dr. Walker, whom General Fraser had employed in Statistical and Natural History researches in the Nizam's territories, considered as appertaining to a coal-formation. General Fraser had previously caused specimens to be sent to the Asiatic Society of Calcutta; but the reports upon them not satisfying Dr. Walker, a second series of the specimens were sent to me by General Fraser, with a request that I would ascertain their possible relations with true coal-strata.

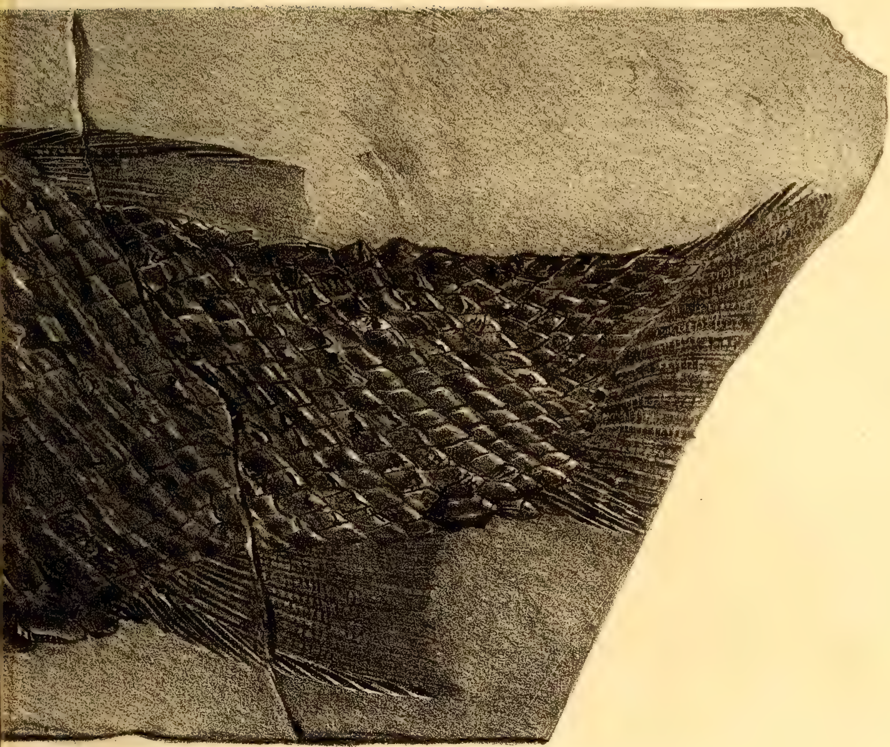
Considering the enormous development of trap, covering some 200,000 square miles in the Deccan,—the granitic basis of the whole Peninsula of India,—the area occupied by laterite,—the want of sedimentary rocks,—and the hitherto total absence of organic marine fossils in the Deccan (for a few shells brought to notice by the late Dr. Malcolmson were either fluviatile or lacustrine),—the discovery of fossil fish on the margin of the trap region was a novelty necessarily of great interest, as indicative of the former submerged state of the Peninsula of India. The fossils arrived in October last, and a glance showed that the remains were imbedded in bituminous schist. The specimens were met with, General Fraser mentioned, near to the confluence of the Wurda and Godavery Rivers, north of Hyderabad and south of Nagpoor. But as the Wurda runs into the Wein Gunga, and the latter runs into the Godavery, General Fraser probably meant the confluence of the Godavery and the Wein Gunga. The junction of the Wurda and Wein Gunga is about 170 miles north-easterly from Hyderabad, in latitude 19° 87′ N., and longitude 79° 50′, and the junction of the Wein Gunga and Godavery is about 115 miles north-easterly from Hyderabad, in latitude 18° 49′ 30″ N., and longitude 79° 56′ 30″. I have reason to believe these localities to be from 1200 to 1400 feet above the sea-level.

The Curator of the Geological Society inspected the specimens of fossil fish, and he considered that they belonged to a genus which in European latitudes is usually associated with the oolitic formation. The oolitic rock nearest to the locality of these fossils is in Cutch, fully 1000 miles distant, and with a thickness of from 4000 to 5000 feet of trap intervening for a couple of hundred miles; nevertheless, many of the European associates of oolite exist upon the Wurda and Godavery; namely, bituminous shale, wood-opal, calcareous spar, rhomboidal quartz, agates, chalcedony, hornstone, &c., and the rock itself may be overlaid by the prodigious flow of trap. It was not until the arrival in town recently of my friend Sir Philip Egerton, whose acumen and critical knowledge of fossil ichthyology render his



Jos. Dinkel, del. et lith.

LEPIDOTUS DI



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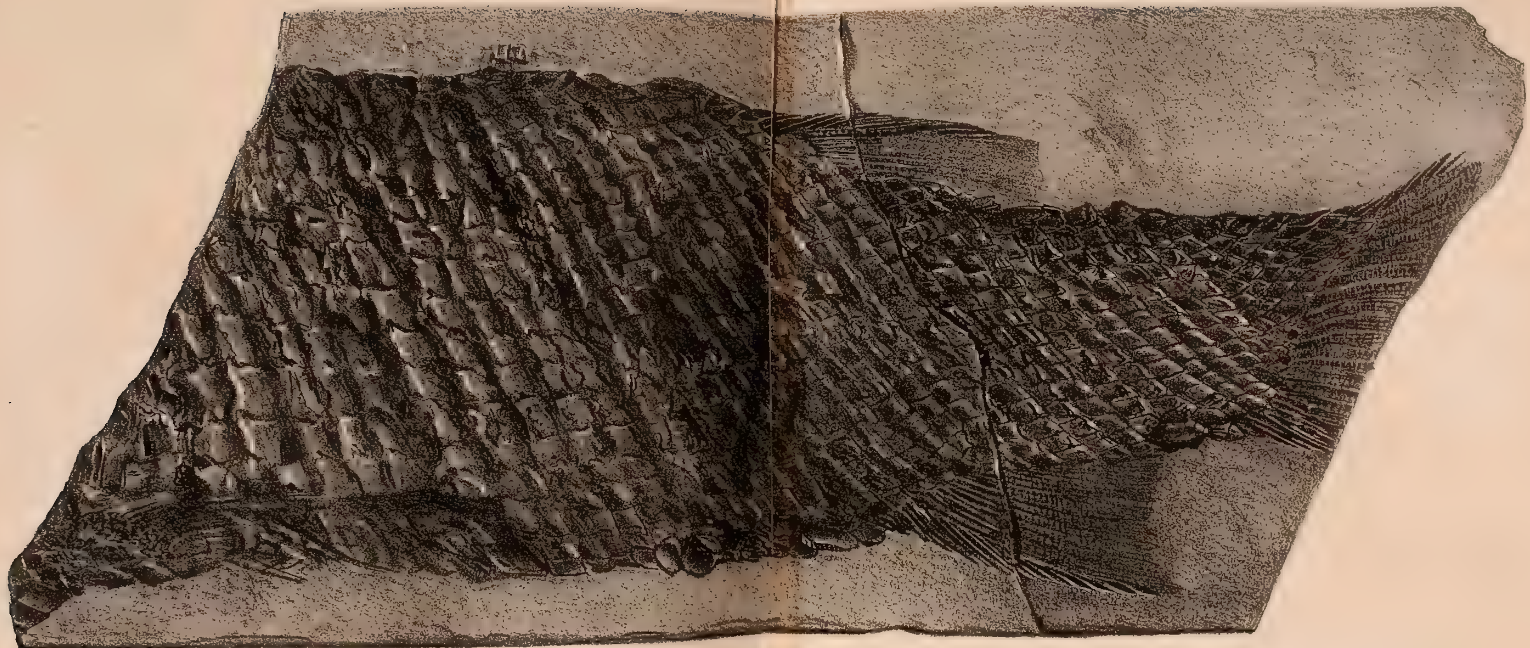
ANENSIS.



Jos Dinkel, del et lith

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LEPIDOTUS DECCANENSIS.

opinion so valuable, that I was enabled to get the specimens examined with deliberate attention. But Sir Philip, with that readiness which makes him at all times anxious to render his knowledge available to others, instantly responded to my appeal, and I am permitted by him to make use in his own words of the conclusion at which he arrived after an examination of the fossils. He says,—

"The specimens, with one exception, are much broken, and the materials scattered confusedly over the schist, but there is sufficient evidence to show that they are all referable to the genus *Lepidotus*, and most probably all to one and the same species, *that being a new one*. It is remarkable for the slender proportions of the anterior part of the trunk, and the thickness of the posterior part between the anal fin and the tail. The scales are perfectly smooth, and the free posterior margins entire, without any trace of serration. A ramus of the lower jaw is seen on one specimen, showing the teeth to be conical, with rather elongated bases. There is little doubt but that it is a true Oolitic form, and apparently of the date of the Lias. The schist in which the fish are imbedded reminds me strongly of the bituminous shales of the Lias of Seefeld in the Tyrol. It is very desirable that more perfect specimens should be obtained, since the only one showing the form of the fish wants the head, and exhibits only the under surface of the scales."

In a second note Sir Philip adds, "The genus *Lepidotus* extends from the Lias to the Chalk, both inclusive; but your species bears evidence of being one of the earlier members of the race. It was probably an estuary or in-shore fish, from its frequent association with terrestrial vegetable remains, as in the Hyderabad specimens."

Sir Philip Egerton has so ably and completely exhausted the subject, as far as the specimens permitted, that it only remains to me to name the new fish; and as it was very much my practice in my Natural History investigations to associate new species with the localities or provinces where they were met with, I would propose to call the specimen *Lepidotus Deccanensis*.

I have written to India for more specimens; but as the discoverer, Dr. Walker, has lately unhappily lost his life by a fall from his horse, I am not very sanguine about their receipt.

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3. *On the Physical Evidence of an* EXTREME ARCTIC CLIMATE *during the Formation of the* ERRATIC TERTIARIES *of* ENGLAND *and* WALES. By J. TRIMMER, Esq., F.G.S.

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

June 25, 1851.

Lieut. H. U. Tyler, R.E., was elected a Fellow; and Signor Angelo Sismonda was elected a Foreign Member.

The following communications were read:—

1. *On the* Drift *at* Sangatte Cliff, *near* Calais. By J. Prestwich, Jun., Esq., F.G.S.

The flat and extensive plain around Calais is composed of Tertiary strata (bearing a close resemblance to the London series), reposing on Chalk and overlaid by a thick covering of flint-gravel. At the small village of Sangatte, three miles W.S.W. from Calais, and immediately opposite to Dover, the chalk rises to the surface, forming the well-known promontory of Blanc-nez. These chalk cliffs were described in the Transactions of the Geological Society for 1820 * by Mr. W. Phillips, who alludes briefly to the large accumulation of flint-gravel, and observes "that this kind of deposit is confined to the summit of the rising cliff, which consists beneath of sand lying in thin beds of different colours"......"but the general tint of the mass is greenish." He continues—"the probability that this sand may belong to the Plastic Clay formation occurred to me, but I discovered nothing beyond the general appearance of the sand to strengthen the suspicion." He correctly notices that this newer deposit abuts against the Chalk. In 1839, M. D'Archiac also noticed these cliffs, and stated that they exhibited a flint-gravel 8 metres thick, overlying 3 metres of a yellowish sandy clay with fragments of chalk—the whole reposing on a bed of deep greenish coloured sand about 3 metres in thickness, unconformable to the Drift above †, and apparently belonging to the Sables Inférieurs, but without fossils to prove it.

When passing through Calais last autumn, I visited Sangatte, for the purpose of examining these reputed Tertiary strata; but either they have been removed by the wearing away of the cliff, or else the greater distinctness of the section prevents me from feeling the doubts expressed by the above-named geologists,—the section, as it now exists, apparently consisting entirely of a variable mass of Drift, bearing a striking resemblance to that of the cliff at Brighton, described by Dr. Mantell in 1833 ‡, and more recently by Sir R. Murchison §. In general structure, colour, materials, and order of superposition, the character of these cliffs is so much alike, that a section of the one might almost pass for that of the other. At the base of the Sangatte Drift, and reposing upon a ledge of Chalk (see Section), is a bed varying from 4 to 8 feet in thickness, and consisting of black chalk-flints, mostly rather large, and all a good deal rolled and worn, but not rounded. With these are some large flattish worn masses of chalk. The whole is loosely mixed with a very small quantity of sand. The peculiar character of this bed is the *uniformity of wear* and the *water-*

* Vol. v. p. 47. † Mémoires Soc. Géol. de France, t. iii. p. 263.
‡ Geology of the South-East of England, p. 31. § May 1851.

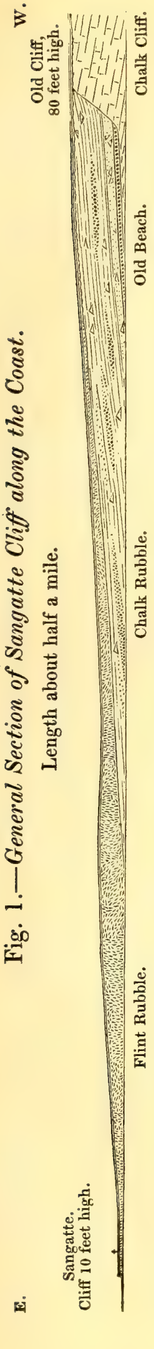

Fig. 1.—*General Section of Sangatte Cliff along the Coast.*

Length about half a mile.

washed appearance of *all* its component materials. In this it resembles any coarse, rough, shingle-beach. I found, however, no traces of any shells in it. Above this more regular bed is a roughly spread mass of chalk-rubble and flint-gravel. The lower part, to a thickness of 50 to 60 feet, consists essentially of a paste of mixed sand, clay, and chalk, of a dirty cream or greenish colour, and with imbedded fragments and masses of chalk, and here and there a large unrolled flint. Subordinate to this mass are irregular patches and layers of angular flint-gravel. The whole is roughly bedded, or spread out, as it were, in irregular sheets. The matrix of this chalk-breccia is liable to frequent variations; sands prevailing at one place, and clays or chalk at another and on the same level*. Occasionally the mass seems composed almost entirely of greenish or of yellow sands, derived probably from the destruction of the lower Tertiary strata.

Overlying this portion of the Drift, but still forming part of the same deposit, is a mass consisting entirely of angular flint-gravel, from 20 to 25 feet thick. The matrix is the same generally as that of the portion below, from which it differs merely by the preponderance of angular flints. It is composed principally of broken chalk-flints, but contains also a considerable quantity of angular flat lumps of a coarse iron-sandstone derived from a deposit of sand and iron-sandstone, outliers of which overlie the chalk on the adjacent hills. It also contains whole, as well as sharply broken pieces of those peculiar green-coated flints which form the lowest Tertiary bed in the north of France and in England. Further, disseminated irregularly throughout the mass, are a few of those perfectly rolled and rounded black flint-pebbles, which were formed at various periods during the Tertiary epoch. These pebbles are sometimes whole, but at other times they are broken, and their edges sharp and without wear.

I met with no fossils in any part of this deposit. My visit to it, however, was very short. In structure and composition it so closely resembles the Brighton drift, and in some measure the drift at Dover, both of which contain mammalian remains,—whilst in the somewhat similar flint-gravel in the Department of the Somme, and also in the gravel in the adjacent part of the English Channel, such remains are not uncommon,—that one of my objects in making this

* Concreted masses, similar to the Combe-Rock of Dr. Mantell at Brighton, are not uncommon in the lower part of the Drift.

communication is to direct attention to this peculiar deposit, in the hope that further research may bring to light remains of a similar description.

In a paper on the Brighton Drift, read before the Society on the 14th of last May, Sir Roderick Murchison expressed an opinion that the accumulation of the Mammalian chalk- and flint-rubble was sudden and tumultuous. In this view I quite agree, and also conclude that the same rapid mode of accumulation is to be attributed to the Sangatte Drift*. For, if the action had been slow and gradual, the rolling to which the broken flints would have been subjected, must inevitably have more or less blunted their edges; and further, any rounded flint-pebbles from the Tertiary strata could only have been more rolled and rounded. But on the contrary, we find in this chalk-rubble broken angular flints with edges as sharp as a knife, and with fractures as clean as though they were just broken with a hammer, whilst the small, hard, *round* flint-pebbles from the Tertiary strata are often broken into two or more pieces, and these pieces neither rolled nor worn. Some which are entire, and likewise many of the flat broken lumps of iron-sandstone, are also found, as it were, standing on end—their longer axes perpendicular to the lower surface of the deposit.

Again, with regard to the finer sediment, if the accumulation had been tranquil, this would have tended to have formed separate and distinct layers; whereas we find an almost impalpable chalk-paste full of small and large angular and rolled fragments of chalk,—and this chalk-paste occasionally replaced by sands apparently of Tertiary origin, almost unmixed, and as though lifted up and transported bodily and without being broken up. The whole mass is roughly stratified into certain divisions; but in each division the materials are mixed together perfectly independently of their specific gravity. Impalpable chalk-silt, which the most gentle current, if maintained, would remove, is found enveloping masses of broken chalk-flints, whilst large massive flints, scarcely at all broken or worn, and requiring for their transport considerable power, are found dispersed indiscriminately in the finest sediment and in the coarse shingle. The flint-rubble is also often heaped or piled as it were together, giving rise to a roughly contorted appearance. Further, a deposition under the ordinary conditions of accumulation in water would have led to the probability of traces of the contemporaneous fauna occurring.

It seems to me probable, that the action which led to the accumulation of this Drift was sudden, powerful, tumultuous, not of long continuance, and suddenly arrested. At the same time I do not believe that it was of a nature to break and fracture the great mass of angular flints; but these having been in greater part broken and shattered by *previous disturbances whilst in the body of the Chalk*, that they were removed, not so much by rolling at the bottom of the water, as by transportation *in mass* with the waters. Such a force, while it would uproot and tear away large portions of the Chalk

* It is also probably of the same age.

and Tertiaries, might, if the distance were not great, transport, comparatively uninjured and unbroken, masses of the softer strata, and even the more delicate shells which they contain. The condition of the mass would depend, therefore, entirely upon the distance upon which it had travelled, and the nature of the ground over which the waters passed.

If we suppose a large body of water to be moving with a velocity sufficient to transport large blocks, then, necessarily, the smaller debris and the mud and silt would be carried along with them; but when the velocity is only sufficient to move the finer debris, then the coarser materials and larger blocks must be left behind. In the former case the heavier portions would subside first, and the lighter ones be carried to a greater distance and become gradually more worn. But let this current be arrested in the early part of its course, and then we shall have a deposit of mingled debris, the less sorted the nearer we approach to its point of origin; and if this should have been effected after a short transport, and without meeting with any material impediments, then masses of clay and sand, with their imbedded organic remains, however delicate, as well as the bones of animals occurring on the surface of the ground, may, I apprehend, be transported comparatively uninjured and unbroken. Should however any impediments occur to obstruct their progress, or any conflicting currents disturb the uniform and regular sweep of the moving mass, then the clash of the debris will more or less break and wear both the organic remains and the rock-detritus in proportion to their hardness and power of resistance; the more friable and delicate specimens being first destroyed, and only the harder bones and rock-debris holding out to the last. The whole mass would also become more intermingled.

In the case of the Sangatte Drift, the materials do not appear to have travelled far, the lower portion of it consisting chiefly of pure chalk-rubble, derived from the adjacent Lower Chalk, and the upper part being full of flints which probably came from a rather more distant point of the same range of hills. The whole mass seems to have been checked and thrown down after but very little wear, and in a manner comparatively independent of the specific gravity of its component parts; whereas, if the action which accumulated these materials had been slow, gradual, and long-continued, they would most likely have been sorted according to their specific gravities; and more particularly as all the fragments in any given layer would have been subjected to a force acting comparatively with equal power, and *in an equal manner*, they would necessarily all exhibit a nearly like amount of wear, varying in the different specimens according to their hardness, but the measure would be alike for all. In this and the analogous case at Brighton, an impalpable chalk-silt would, I apprehend, be incompatible with coarse siliceous sands—worn pebbles with sharp angular flints—the largest debris with the finest—and entire and perfect bones with others, some of which are broken and others rolled and worn.

At the same time the bed of chalk-flints which reposes immediately on the Chalk is, as at Brighton, so distinctly waterworn and washed, that the long-continued and quiet action of the sea on them can hardly be doubted. It is apparently an old sea-beach, ending rather abruptly against an ancient chalk-cliff *, and about 10 to 12 feet above the level of the present beach (see A. fig. 1). The transition from this bed to the overlying mass of drift is sudden and abrupt. In the first place, it is evident that the same sea which washed the base of this old cliff—carrying away the chalk, and leaving the heavier flints spread out on a sloping shore—could never have formed, whilst its conditions remained unchanged, the superimposed 60 to 80 feet of rubble. Nor is there any evidence of a quiet depression of the land, and consequently of a gradual extension upwards of the conditions which prevail below. The change, on the contrary, is sudden and complete, and maintained throughout the whole of the overlying mass which has accumulated against the face of the old cliff—burying and not levelling it—neither forming successive zones or steps on it.

What may have been the causes which led to this result, or the exact mode of operation, is another question. It is one which we can expect to solve only by collecting a number of facts of this description; and afterwards, by sorting and grouping the data we may thus obtain, we may hope to arrive at some of the more general laws relating to this important and interesting problem. The observations of Mr. Austen have already furnished us with many valuable details bearing upon this point on the South Coast of England; the Drift at Sangatte, and much of that described by Sir R. Murchison in his recent paper, agreeing apparently with that which Mr. Austen has described in a number of other localities under the designation of Subaërial beds †. Whether, therefore, this class of phænomena indicates, as I believe, sudden and tumultuous sub-aqueous action, or whether they are to be attributed to the more ordinary and tranquil causes in operation in the waters or on the surface, their extent and importance cannot be overlooked, and will, it is to be hoped, lead to further inquiry.

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2. *On the* Gravel-beds *of the* Valley *of the* Wey.

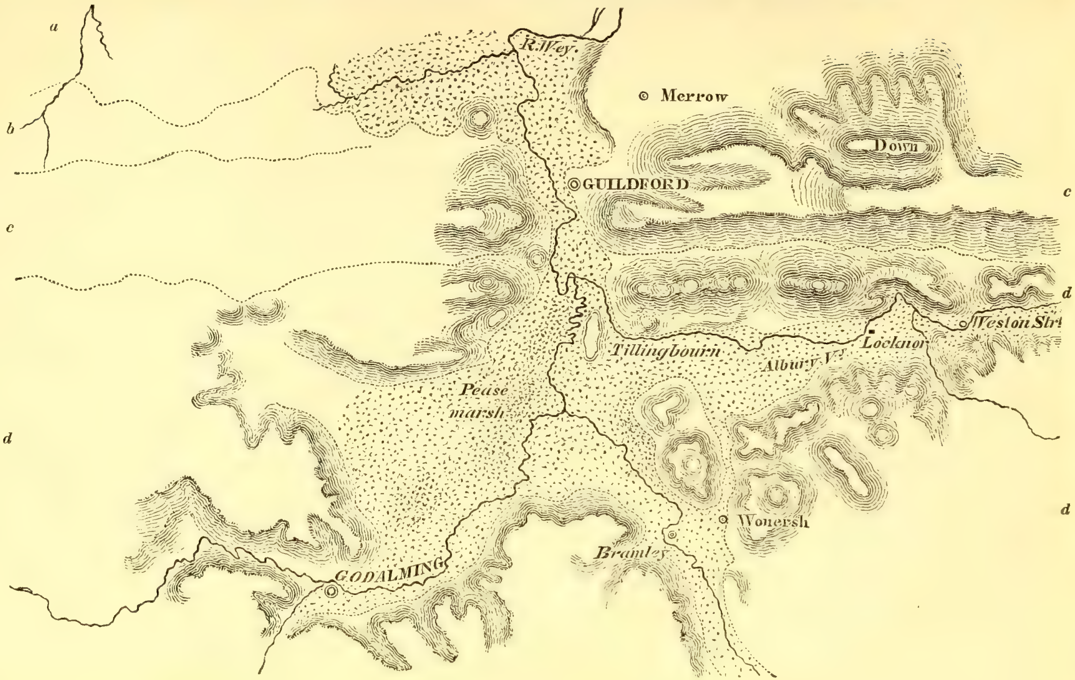
By R. A. C. Austen, Esq., F.R.S., G.S.

The river Wey takes its rise within the area of the Wealden denudation, of the north-western portion of which it conveys away the waters into the London basin through the break in the chalk-range at Guildford. The portion of the valley of the Wey which mainly furnishes subject-matter for the present communication lies immediately south of Guildford, towards Godalming.

* The course of the old cliff inland requires to be traced. This is difficult, as the great accumulation of drift has rendered it flush with the present surface of the land, which forms level fields in which there are no excavations.

† Quart. Journ. Geol. Soc. vol. vii. p. 118 *et seq.*

Fig. 1.—*Map of the Guildford Valley, showing the Extent and Distribution of the Gravel Beds.*



a. Gravel-beds, continuous with those of the Wey Valley.
b. Lower Tertiaries.
c. Chalk.
d. Lower Greensand.

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.

To the east of Farnham there is a depression of the chalk-strata for an interval of a mile; towards this point one of the upper branches of the Wey, known as the Farnham River, comes down in a direct course from its source, near Alton, and would flow out into the London basin but for an intervening difference of level of very small amount, and which causes the stream to turn away at a right angle in the direction of Waverley. The line of valley from Farnham to Alton belongs to the system of disturbances which attended the Wealden elevation *. In this upper portion of the valley of the Wey we have a repetition of all the phænomena of the Guildford Valley with respect to the limited distribution, composition, and arrangement of the gravel-beds, so that it will not be necessary to give any detailed description of them ; and for the same reason, the gravel-beds of the valley of the Mole, at Dorking and Betchworth, will need only incidental notice. It would require a great extent of illustration to show the detail of the distribution of these gravels from Alton to Reigate, and their dependence on the external configuration of the district. Such detail cannot be attempted here, besides which independent observers need no longer trouble themselves to map out and define the boundaries of geological groups, inasmuch as the Government has undertaken the task.

Sir R. Murchison has lately (in a paper read before the Society May 14, 1851) brought forward some views respecting the *convulsive* character of the Wealden elevation, and has appealed to certain lines of gravel-beds as the evidences of such forces : another distinguished geologist has long supported his theory of the Wealden denudation by a reference to an accumulation of the same age as that of the beds to be here noticed †. I neither propose in this place to offer any observations on these views, nor to substitute any speculations of my own as to the Wealden area; but simply to show that the accumulations in question are perfectly distinct, as to age and origin, from those which resulted immediately from the spoil of the Wealden denudation, and that this area had acquired its main physical character at some time anterior to the distribution of these gravel-beds. I am the more anxious that this fact should be fully appreciated by geologists, from its connexion with the physical geography of the South of England during the Upper Tertiary period.

The external physical features of the valley south of the break in the chalk at Guildford are represented on the Map, fig. 1, and its geological structure has been already described ‡. The slopes of the hills which surround this area are remarkably steep. When viewed from their summits, the bottom of the valley has the appearance of a perfectly level plain ; it consists, however, of two platforms—an upper and outer one, and a lower or central, along which the river Wey now takes its course : the difference of level is trifling, not more perhaps than 12 feet, but it is marked by an abrupt descent from one to the other. The whole of this area, to the base of the steep

* Quart. Journ. Geol. Soc. vol. iv. p. 260.

† Principles of Geology, 1833, vol. iii. p. 285 *et seq.*; Manual, 1851.

‡ Proc. Geol. Soc. vol. iv. p. 170.

slopes, is occupied by beds of stratified sand and gravel, which suggest the speculation that they have been spread out uniformly by the action of a mass of water, which at some time occupied the whole of the valley, and that a central portion of the accumulation has been since removed.

In the Pease-marsh portion of the valley, as on both sides of the Portsmouth road, the gravel-beds rest on Weald-clay; in other places they are on Neocomian beds, and towards the edges of the denudation they are on portions of the Lower Greensands. These beds, and throughout their whole thickness, exhibit the ordinary and unmistakeable characters belonging to such as have been arranged beneath water of no great depth;—the materials are coarse and waterworn, are spread out horizontally in successive seams or layers, and, what is of the greatest importance as evidence of a gradual process of accumulation, is the circumstance that *interposed beds of sand occur throughout, having a diagonal arrangement.*

The thickness of this accumulation depends on the inequalities of the surface on which it rests, and varies from 3 to 25 feet; yet there is a general order of succession to be observed, as follows:—

1. Black vegetable earth; peat; bog-iron-ore.
2. White and grey marls.

3. Brown and red clay.

{ 4. Fine gravel and sands.
{ 5. Coarser gravel and drifted sands (diagonal); blocks of Sarsden stone; teeth and tusks of elephants, single and rolled.

6. Peaty mud, with wood; (local).

It must be understood that the upper part (1, 2) of this series is local; the lower (3, 4, 5), however, is constant.

Throughout the whole of this area, which is comprised within the Lower Greensand ranges, the material of the gravel is of rounded or subangular chalk-flints. With it is iron-stone, chert, and Bargate sandstone. There is also in places much small shingle of quartz and lydian-stone, which has been derived from the conglomerate-beds of the lower greensand. There are also occasionally large rounded blocks of greywether sandstone, breccia, and pudding-stone from the lower tertiary series. In the distribution of these materials, the principal mass of pure flint-gravel will be found opposite to, or in the line of the gorge at Guildford, as along the line of the railway-embankment, and on the Pease-marsh: along the several branches of the valley, the proportion of materials from the lower greensand increases: near Godalming, in the last railway-cutting, some rearranged sands had so completely the look of undisturbed greensand, that, but for the mammalian remains, they could not have been referred to the gravel. From this short account of the position and arrangement of the gravel-beds in the Guildford Valley, we may deduce some general considerations as to one stage of a former condition.

It is absolutely necessary towards the production of strata or beds with diagonal lamination, that there should be an onward movement of the whole body of water, such as that of a stream-current. I have elsewhere suggested that the cross-lamination, which certain marine deposits exhibit over wide areas, may be referable to the more rapid and effective tidal action of enclosed and moderately deep seas. If, in the instance of the Guildford Valley gravels, this form of arrangement was due to currents of water produced by streams, which flowed into that area from the central Wealden region, and which discharged outwards through the gorge in the chalk-range, the direction of such currents being constant, that of the laminæ would be so also, or northerly; whereas we constantly find them dipping southerly, as if the prevailing set of the water when in movement had been from the north. The gravel-beds, here described, pass through the gorge at Guildford, and are continuous and identical with those which cover the whole of the London-area-basin; we have, therefore, a definite water-level, or, in other words, the Guildford Valley was a land-locked bay of that great northern ocean, of which the "drift-gravel" beds are the sub-littoral accumulations. Under these conditions the process of accumulation would have been identical with what now takes place in all deep bays or estuaries along sea-boards; whilst under the other supposition, the mechanical power of a perfectly enclosed area of water of the dimensions of that here described (Map, fig. 1) could never have conveyed and arranged the beds of gravel as we here find them. But definite geological epochs are very indefinite periods of past time; and no one representation of ancient physical conditions can hold good for more than one portion of a geological period: in this case we have the distinct features of the old bay, the gorge communicating with the external area of water, its *latest* level, and mechanical arrangements; but it by no means follows that the materials so disposed were for the first time placed there. There are good grounds for the supposition that there was here an anterior and very different configuration.

It will be seen by the tabulated order of succession (p. 281) that there is a progressive change from coarse gravels up to fine clay, a change which indicates a diminution of moving power; but this result may be brought about, whether the displacement of a portion of the volume of water happen from elevation on the land side, or by the simple process of filling up, the water-level remaining the same throughout.

It will be also seen from the Map, that the gravel-beds, here noticed, extend some way up several valleys which branch off from the main one; of these, that of the Tillingbourne stream, which extends some miles in an easterly direction, offers some points of interest. The general slope of the ground, covered by gravel, is to the north, and this slope is occasionally considerable, as in the section from above Locknor Farm to the stream at Collyers Hanger (fig. 2). The Locknor cutting, on the Reading and Reigate Railway, is 31 feet deep, of which the greater portion was through layers of gravel with beds of diagonal drift-sand. This cutting is perhaps at the highest point at which these beds have been noticed, being rather more than 130 feet above the great collection of flint-gravel at the level of the canal, or 241 feet above the sea. The angle of slope from the top of the Locknor cutting to the stream, although considerable, is not perhaps greater than that on which gravel-beds might accumulate, but the difficulty they here present is this, that along the whole of this section the thickness of the gravel-beds, which has been proved by numerous deep drains, was found not to exceed 4 or 5 feet in the lower portion of the valley. The section across the valley at this place, at the time when the gravel-beds were accumulated, could not have presented the same conditions as at present, inasmuch as the thickest beds would have been collected in the deepest portion, whereas we have seen that they occur at what is now the highest; nor are they ever found to have an elevation on the north side of the valley corresponding to that on the south (see Section, fig. 2).

I therefore infer that when the gravel-beds were accumulated, the condition of the Tillingbourne Valley was not such as it is now, but that the slope of the beds has been imparted to them since. It will be observed that the gravel-beds end off abruptly at the base of a steep escarpment of the lower greensand (fig. 2); and this feature I consider to be due to a fault, the upcast of which being to the north would be attended by a depression on the south, and thus place the gravel-beds as we now find them.

I had often heard from persons in the occupation of lands along the Tillingbourne Valley, that the surface subjacent to the gravel-beds presented a series of long parallel furrows or troughs, running in the direction of the valley, or east and west; this was ascertained in draining the land, and it is now found sufficient to cut across these troughs, and thus allow the water they hold to run off. It was only very lately that I had an opportunity of seeing the true character of the surface-outline here described.

The place at which the Section, fig. 3, is taken is about half a mile west of the position last-noticed (Locknor cutting), and the gravel-beds, instead of dipping north, are separated into two masses by the rise of a ridge of Neocomian clay, *d*. The southern mass is trough-shaped, the other slopes towards the stream or northerly, in which direction it also thins away. The gravel-beds rise to this ridge on either side: this position might be considered by some as the result of accumulation on an uneven surface. Coarse materials can hardly, however, be supposed to have taken and preserved such steep angles beneath the levelling action of water which had a considerable moving power, for the greatest angle of slope was 46°, and I am therefore inclined to consider that the appearances shown in Section, fig. 3, must be the result of disturbances which have taken place since the first accumulation of the beds.

The summit of the ridge of Neocomian clay presents a deep fissure filled with gravel (see fig. 3, *g*).

I should hardly have been satisfied with the evidence here adduced, as to the comparatively recent date of some of the disturbances of this district, had it not been for the *fault* (*f*) which the S. extremity of the Section, fig. 3, presented. This section was taken from a large quadrangular excavation, made for the offices of a dwelling-house; the

Fig. 2.—*Section of the Tillingbourne Valley.*

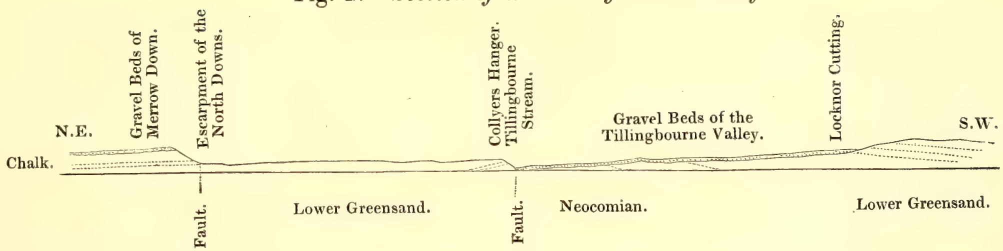
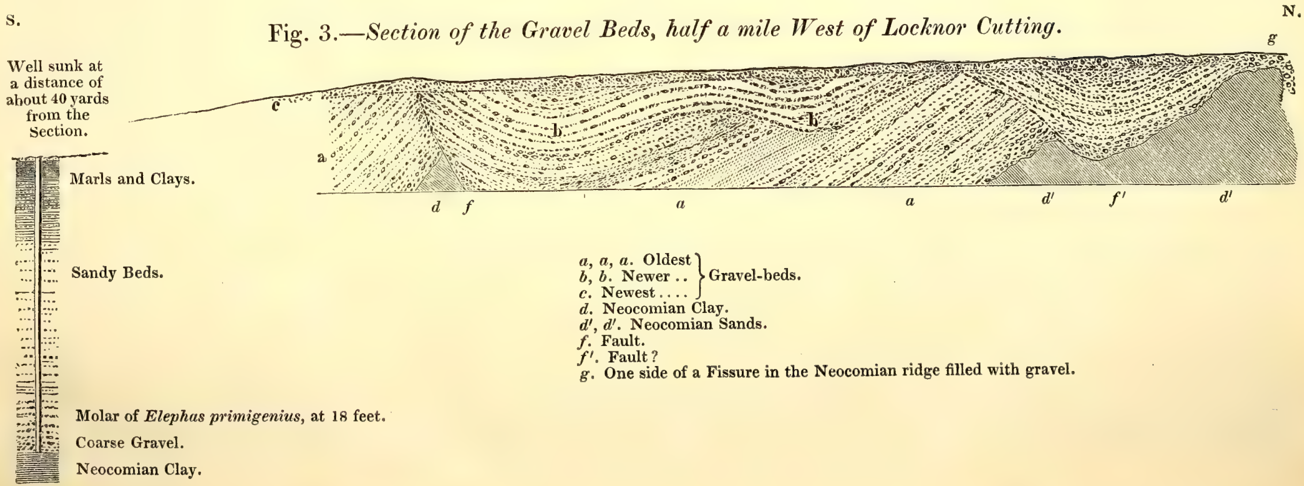


Fig. 3.—*Section of the Gravel Beds, half a mile West of Locknor Cutting.*



a, a, a. Oldest } Gravel-beds.
b, b. Newer .. }
c. Newest .... }
d. Neocomian Clay.
d′, d′. Neocomian Sands.
f. Fault.
f′. Fault?
g. One side of a Fissure in the Neocomian ridge filled with gravel.

floor of the excavation was worked to a true level, with vertical sides, presenting clean sections from 5 to 8 feet deep. The opposite section, or that on the E., corresponded with the one here given as to the composition of the beds of gravel, and their position. The southern end of the section (fig. 3) presented a dislocation (*f*). It will be seen that there is a downcast to the north and an upcast on the opposite side of the subjacent strata, which here consist of hard Neocomian beds, *d*. The stratification of the gravel-beds was distinctly marked, and the position of the pebbles in the different layers much disturbed on either side of the fault. As the materials from this excavation were all reserved for various purposes, but from which it was desirable to exclude any clay, the workmen avoided the mass marked *d*, so that it was left as a ridge or dyke crossing the excavation from E. to W., in which state I first saw it: the section, however, was taken after it had been cut away. The existence of this particular clay-ridge was previously known, from the area of wet land it caused to the south of it; and whatever may be the case with respect to these clay-ridges at other places, it is clear that this one has been produced by a fault subsequent to the accumulation of the lower gravels. To the south of this spot the gravel-beds increase in thickness, so that at about 30 yards a well there sunk did not pass through them at a depth of 15 feet.

Although I had long since satisfied myself that the accumulations of the age of those here described have been everywhere displaced since their original deposition, yet I should have hesitated, even until recently, as to whether such a statement—as to faults traversing superficial gravel-beds—could be made. Such a section as the one here figured is sufficient evidence on this point; but it is not the only evidence which these gravel-beds afford us. Whoever will closely examine any sections of the beds here in question (the one here given, fig. 3, is sufficient), will perceive that there are *clear indications of changes of position during the progress of the accumulation*. This is a subject respecting which I hope shortly to bring before the Society a considerable mass of evidence taken from an examination of the drift-sands and gravels of the whole of the South of England: for the present it will be sufficient to draw attention to the section here produced, and which is a fair illustration of the phænomena which constitute the evidence of the case.

In Section, fig. 3, we may safely assume that the lower beds (*a, a*) have a higher angle than that at which they were accumulated, or that their present position is the result of some disturbance; of this the fault (*f*) is further confirmatory. The portion of the gravel marked (*b*) is of subsequent date to such disturbance: whilst the upper levelling of the surface implies conditions perfectly distinct from these two antecedent ones. We meet with no indications of intervening surfaces of dry land, or other guide by which to estimate the extent of time which may have separated these conditions, but other considerations would render it most unsafe to assume that the disturbances here indicated all took place whilst the area supporting these accumulations of gravel was *continuously* submerged.

These gravel-beds are continued from the Locknor cutting, and a clear cross-section (north and south) is to be observed at the entrance into the village of Weston Street. The beds here have a considerable thickness, and present the like general arrangement of horizontal layers of sands and waterworn materials to be observed throughout. With respect to composition, however, they present a peculiarity deserving of notice. Along the Albury Valley the proportion of chalk-flints to other material derived from the subjacent sands is very considerable; but in the Weston-Street section we meet for the first time with rounded and waterworn detritus of chalk. This material is not mixed with the general mass of detritus, but occurs in layers: it should be noticed that it is the *upper portion* of the gravel-beds which is here exposed. It will be seen that this section occurs at the only spot at which, by means of a transverse valley, there is a communication between the valley of the Tillingbourne stream and the base of the North Down range. The gravel-beds are continued up the transverse valley, but they gradually become more exclusively composed of chalk: at one place a mass is to be seen composed of subangular fragments, in which the parting seams alone are of sand, although resting on the iron-stone beds of the lower greensand. It would thus seem that during the accumulation of the higher gravel of the Albury Valley, materials from the chalk-range were brought down from time to time and interstratified with it, showing that this configuration of a transverse depression in the lower greensand range must have existed at the time of the arrangement of the *uppermost* gravels.

The materials which compose these gravel-beds are derived from the Cretaceous series, and are local, with the exception of the blocks of greywether sandstone and breccia. These are much waterworn and of considerable bulk; they occur in every part of the area described, not only in the open valley of the Pease-marsh, but along the valley of the Tillingbourne, and are very common along the line of Section, fig. 2. The supposition that this area was at one time an enclosed bay will account well for the general arrangement of the upper portion of the gravel mass, and some materials may have been conveyed into such an area from without through the gorge in the chalk-range. We have little warrant, however, for assuming that this took place to any extent. The greywether blocks cannot be brought under any such supposition; their weight exceeds the moving power of any limited area of water, and their presence there must be otherwise accounted for.

It has been shown that the gravel-beds supply evidence of movements which must have taken place during their accumulation. It will be seen by reference to fig. 2, and it has been already stated, that the steep slope which the lower greensand presents at this place must be of subsequent date to some portion of the gravel-beds. The chalk-range supports up to its very edge thick beds of coarse gravel and drifted sands, with great included blocks of greywether sandstone—in all these respects corresponding with the gravel-beds of the Tillingbourne Valley below. Add to this the great fault which accompanies the chalk-escarpment throughout, and we can require the admission, that there must have been here also a movement of subsequent date to the first accumulation of gravel along this line, inasmuch as the beds on the chalk-range contain abundantly iron-stone, chert, and sandstone derived from the lower greensand, and that *at elevations above any part of that series now*.

The detail of such considerations as these belongs to the history of those changes out of which the present features of the Wealden area —physical and geological—have resulted. All that I would here impress on geologists is this:—1st, that the gravel-beds which surround the Wealden represent a vast period of time; 2nd, that during that time disturbances took place which altered entirely the relation of the country to the Wealden area within; 3rd, that the inner line of gravel-beds belongs mostly to a form of the surface *when the present bounding ranges or escarpments had not been raised*; and 4th, that where the gravels present a conformity to existing physical features, they are the re-arranged beds which have been derived from, and rest unconformably on, the older ones.

In all the observations which I have lately offered on the subject of the superficial sands and gravels of the South of England, I have restricted myself to such masses as could be referred to two definite periods in past time—either to that of the sub-aërial conditions which were synchronous with the occupation of this country by the large extinct mammalia, or that of the subsequent sub-aqueous accumulations in which the rolled and fragmentary remains of this fauna have been found. As I am well aware that some experienced geologists are disposed to refer certain accumulations of gravel which occur about the Wealden area to the period of its denudation, of which they represent the spoil, and as beds such as are here described might seem suited to support such views, it may be as well to state that remains of the large mammalia have been found over the whole of the area of the gravel-beds here described, and that the line of Section, fig. 3, afforded a fine molar of the true *Elephas primigenius**.

The gravel-beds in the upper part of the Valley of the Wey, at and above Farnham, those below Guildford at Send, and those of the Valley of the Mole near Dorking and Betchworth, have all been found to contain abundantly the teeth and tusks of *Elephas primigenius*; the molars in particular are often much waterworn. But inasmuch as these accumulations seem to have a chronology of their own, it is evidently desirable that the precise positions in which all animal remains occur should be ascertained: this is a point on which unfortunately our information is deficient: as a general rule they are met with in the *lower portions* of the gravel-beds, Section, fig. 3; but it is also possible that in some places the whole thickness of the gravel may be referable to what is the upper and re-arranged gravel of places where the series is complete: this is a point for more accuracy of observation than has yet been applied to these beds.

In the notice of the external features of the surface of the Peasemarsh Valley, it was stated that it had been excavated along a central

* Prof. Owen kindly examined this specimen and also a lower jaw (from some higher beds), which he determined to belong to *Bos longifrons*.

portion; a like observation may be extended to all the gravel-beds of the Wealden valleys. The fact may be observed on either side of the gorge at Guildford, along the Valley of the Mole from Dorking upwards; and it is exhibited in a remarkable manner near Farnham, both descending towards More Park, and in the contrary direction. It was necessary to notice this circumstance here, but its explanation belongs to the history of these valleys subsequent to the date of the gravel-beds.

The gravel-beds which have been here described are usually found overlying clean surfaces of compact sand and Neocomian clay; but in the Pease-marsh portion of the valley, where the upper beds of the Weald-clay are exposed, we meet with a bed of compact dark mud, containing vegetable matter, fragments of branches of trees, and the bones of animals (Ox, Elephant) uninjured and lying together: it is evident from this that the condition of the surface before the accumulation of the gravel was a terrestrial one, and that this was coincident with the occupation of this country by the large extinct mammalian fauna.

The brown and red clays which so commonly surmount the gravel-beds will be recognised as the equivalents of those of the London basin area, which hold a like position. They indicate conditions of tranquil deposition, which is all that can be said of them at present. Higher than these last, and influenced by the form of surface, are certain local accumulations of peat and marl, containing the remains of a fauna belonging to the actual period, such as horns of Deer, and the specimen of *Bos longifrons*, referred to in a note above.

The accumulation of chalk-detritus, which has been noticed in the account of Weston-Street section, can be traced up the transverse valley to the base of the chalk-range, having frequently the character of subangular fragments. The land shells which they contain suggest further inquiry and research: at present these beds of chalk-rubble have yielded a very poor testaceous fauna compared with that from the uppermost bed of superficial soil.

It forms no part of the present communication to explain the nature of the Wealden denudation. Sir Charles Lyell still maintains the view that the denuded area was once occupied by an expanse of water of which the escarpments of the chalk were the bounding cliffs, and in immediate juxtaposition to this view, and as proof and illustration of the theory, he describes the gravel-beds at Barcome. It may suffice for the present to state that this accumulation contains the remains of the large mammalian fauna, and that in every respect its history is identical with that of the valley-gravels of the Wey and the Mole.

3. *On the Occurrence of the* Boulder Clay *in the* Limestone Quarry, Linksfield, Elgin, N.B.* By Capt. Lambart Brickenden, F.G.S.

As there has been observed near Elgin, Morayshire, a very singular phænomenon connected with the Boulder-clay Formation, which is seen to occupy a position that could only have been attained under very remarkable circumstances, I think that a communication on the subject may not be devoid of interest to some of the members of the Geological Society. The rock which prevails around Elgin is referred to the Upper Division of the Devonian system; and at Linksfield, which is a farm north of the town, the superior beds of that formation appear in the character of a limestone, which is very extensively quarried for agricultural purposes. In order, however, to raise the limestone, it is necessary to remove an overlying formation, about 40 feet deep, composed of a series of Oolitic beds, in themselves of great geological interest. Now it is between the limestone of the Devonian system and the strata of the Oolite that the phænomenon exists which is the subject of this notice,—being an extensive intercalation of Boulder-clay, which since the opening of the quarry has been penetrated beneath the incumbent horizontal beds, to the extent of 120 yards, with no appearance whatever of its termination; and this distance is measured in a direction at right angles to the course pursued in its excavation; whilst in a transverse line or section of the quarry, the intercalated mass has been observed to extend nearly 300 yards. The surface of the clay is very irregular and uneven, and its thickness varies from 2 to 4 feet; and I am assured by an intelligent old man, who has visited the quarry very constantly since it was first opened about thirty years ago, that at the distance of more than 100 yards from where it now is the clay was observed to be about the same depth, and overlaid, as now, by the same series of Oolitic strata in their undisturbed position. On the north-western boundary of the quarry the thickness of the intercalation increases considerably, and there can be little doubt that in this direction the clay obtained an entrance.

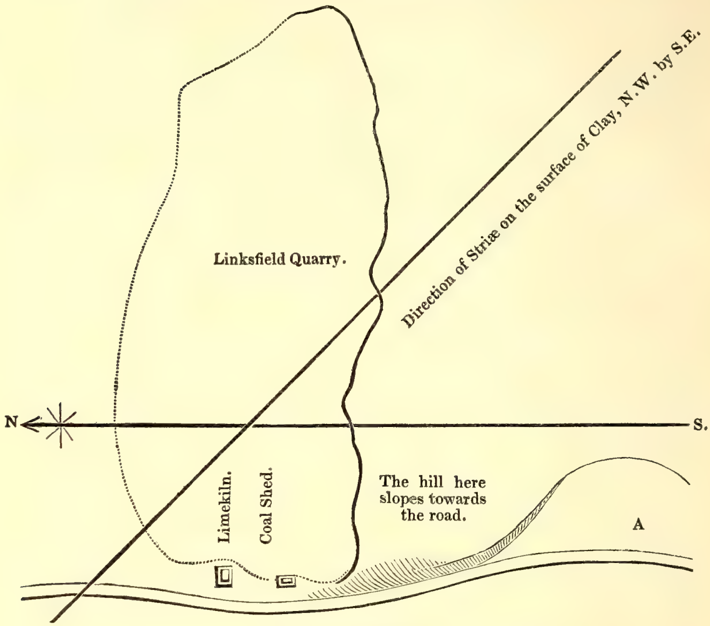
That the drift, thus alluded to, has been forced into the place it now occupies is the opinion generally entertained by those who have examined it; and this appears to be fully sustained by certain peculiarities which the bed discloses, although it is not very easy to conceive the exact manner in which such an extensive and marvellous intrusion was effected. The surface of the Boulder-clay, and also of the strata between which it has been propelled, is hardened, abraded, and marked with polished striæ, indicating the direction in which the mass has moved, which is nearly from north-west to south-east, or in a line at right angles to the natural escarpment of the hill and outcrop of the strata. The clay, moreover, contains the debris of the *upper* as well as of the *lower* formation, and it is identical in colour

* This communication was a sequel to a paper on the same subject read before the Society November 20, 1850, and withdrawn by the Author. Both communications are now printed together.

and composition with the Boulder-clay, which so abundantly prevails on the declivities of the neighbouring hills. In the sectional view of

Fig. 1.—*Plan of Linksfield Quarry.*

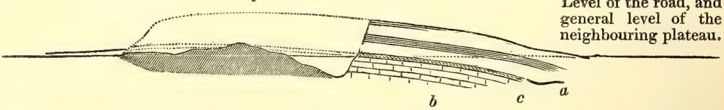
Length of the Quarry from east to west 270 yards.



A. At this spot the Limestone was formerly removed, and the *Intercalation* was here seen.
The dotted line shows the extent of the area in which the Limestone, Drift, and Oolites have been quarried.

Fig. 2.—*Section of the Quarry on the line N.S. of the above Ground-plan.*

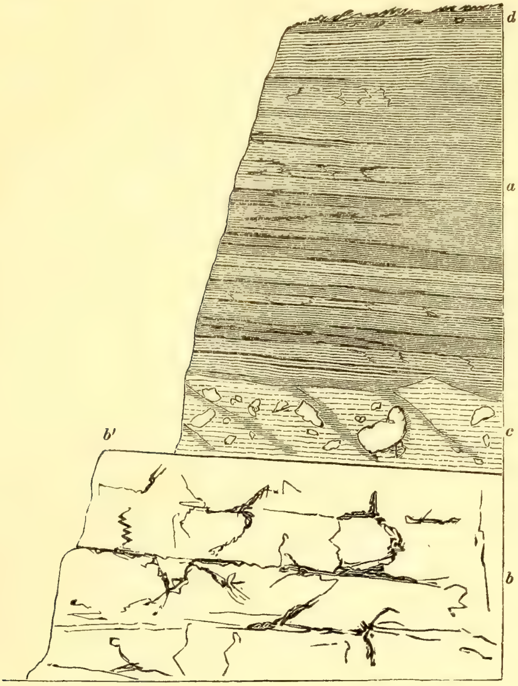
Length of the Base-line 350 yards.



a. Oolitic rocks.
b. Devonian Limestone.
c. Intercalated Boulder-clay.
The dotted lines indicate the portion that has been removed.

it which the stone-pit affords, its bright red tint contrasts strikingly with the dark and sombre hues of the oolites, and with the subjacent whitish limestone.

Fig. 3.—*Section taken at a right angle to the face of the Escarpment; Linksfield Quarry.*



a. Oolitic series.
b. Devonian Limestone.
b′. Polished surface of the Limestone.
c. Intercalated Boulder-clay, with oblique seams of purple clay.
d. Superficial Drift and Alluvium.

Having thus stated a few particulars regarding the intercalated drift at Linksfield, and presuming that, by the various appearances which it exhibits, the fact of its intrusion into the position it now occupies is established, it becomes a very interesting matter to inquire in what manner and by what external force such intrusion has been effected. We can imagine that a mass of yielding clay, arrested at the base of an escarpment or outcrop of strata, might have been injected between them, in much the same manner as igneous or molten masses between some of the stratified formations, provided that certain conditions were fulfilled, of which the chief would be that the propelling power should exceed that of the resistance opposed to it, and that the movement of the injected mass should be confined wholly to the interstratified position referred to. I therefore presume that the Boulder-clay, having originally accumulated at the base of the oolitic outcrop at Linksfield, and having gained an entrance into the position held by its softer and subjacent beds, had been subjected to the action of vast and extensive masses of ice, which, by continuing to press onwards the accumulations of clay retained beneath it, had, by superior force to that which the Oolitic beds could offer in resistance, eventually produced the phænomenon at Linksfield.

Upon the first cursory view of the strata above described, it is naturally supposed, that the intercalated Boulder-clay, lying between the Devonian limestone and the oolites, must be some bed of Conglomerate or Drift of the latter, and to which a slip of the upper strata had imparted a striated character; but the apparent identity of the intruded mass with the superficial Drift or Boulder-clay of the district forbids such an interpretation. However, to avoid perpetuating a mistaken view of a fact sufficiently remarkable to be worthy of record, whatever be its true explanation, I beg to lay before the Society specimens taken by myself from the intruded mass.

The specimens exhibited to the Society were taken from the bed described above as being intercalated between the Oolites and Devonian Limestone. Fragments of the latter rock, showing its polished and striated surface, accompany the samples of the Clay-bed with its included pebbles. Amongst these may be detected fragments belonging to the *upper beds,* as well as of *the ordinary pebbles of the Boulder Formation,* which, with large erratics, are dispersed irregularly through the clay, and these are not unfrequently marked with grooves. There are also seams of a dark purple-tinted clay pervading the intercalated mass, which, when seen on the face of the escarpment, appear nearly horizontal, but, in the section at right angles to it, are found to incline inwards at an angle of about 45°. These seams are partly composed of what the natives call the "Cutley-clay," which is the lower stratum of the incumbent series, and which seems to have been thus displaced and carried forward by the intrusion of the Boulder-clay.

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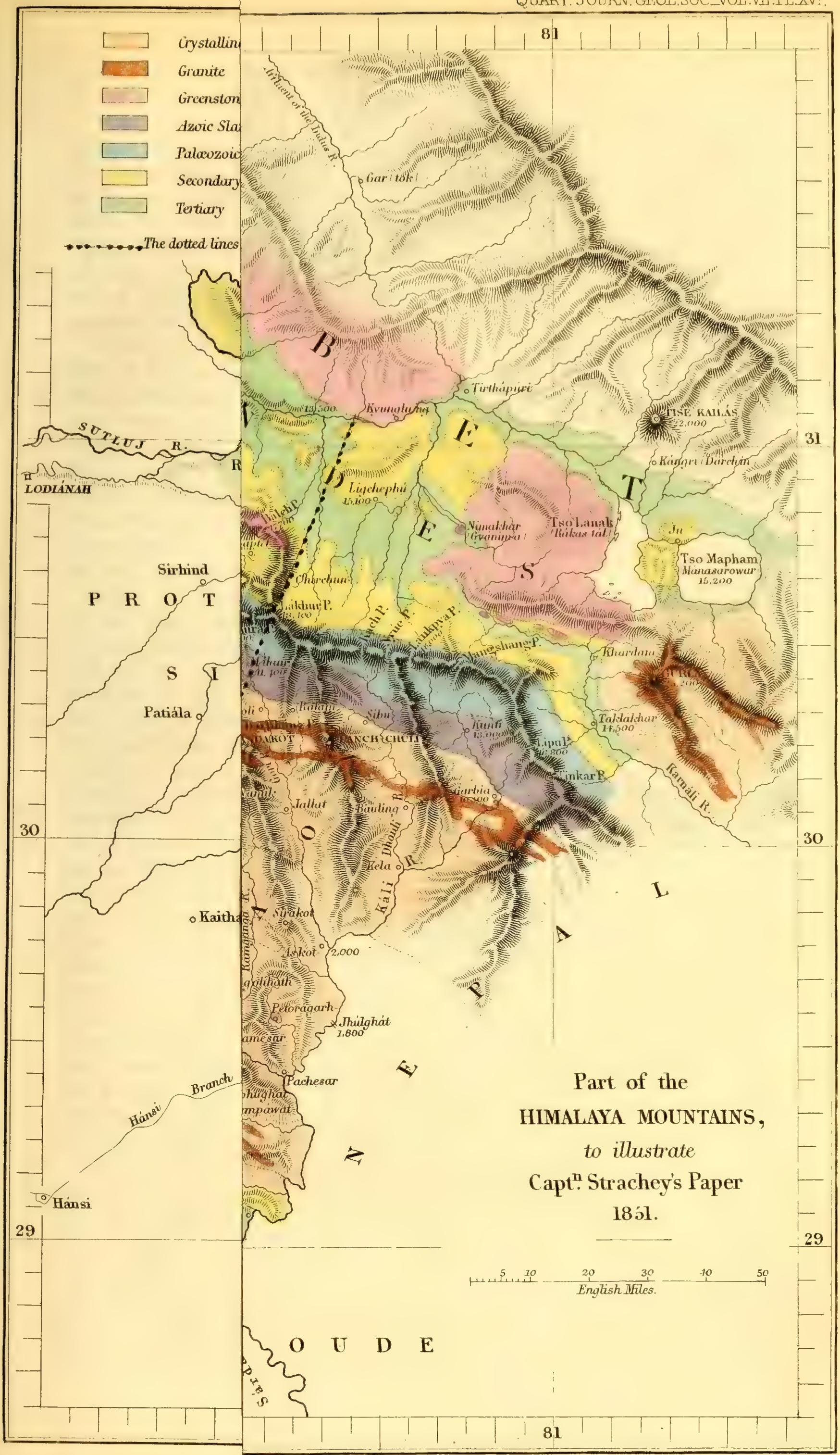
4. *On the* Geology *of Part of the* Himalaya Mountains *and* Tibet. By Captain Richard Strachey, Bengal Engineers, F.G.S.

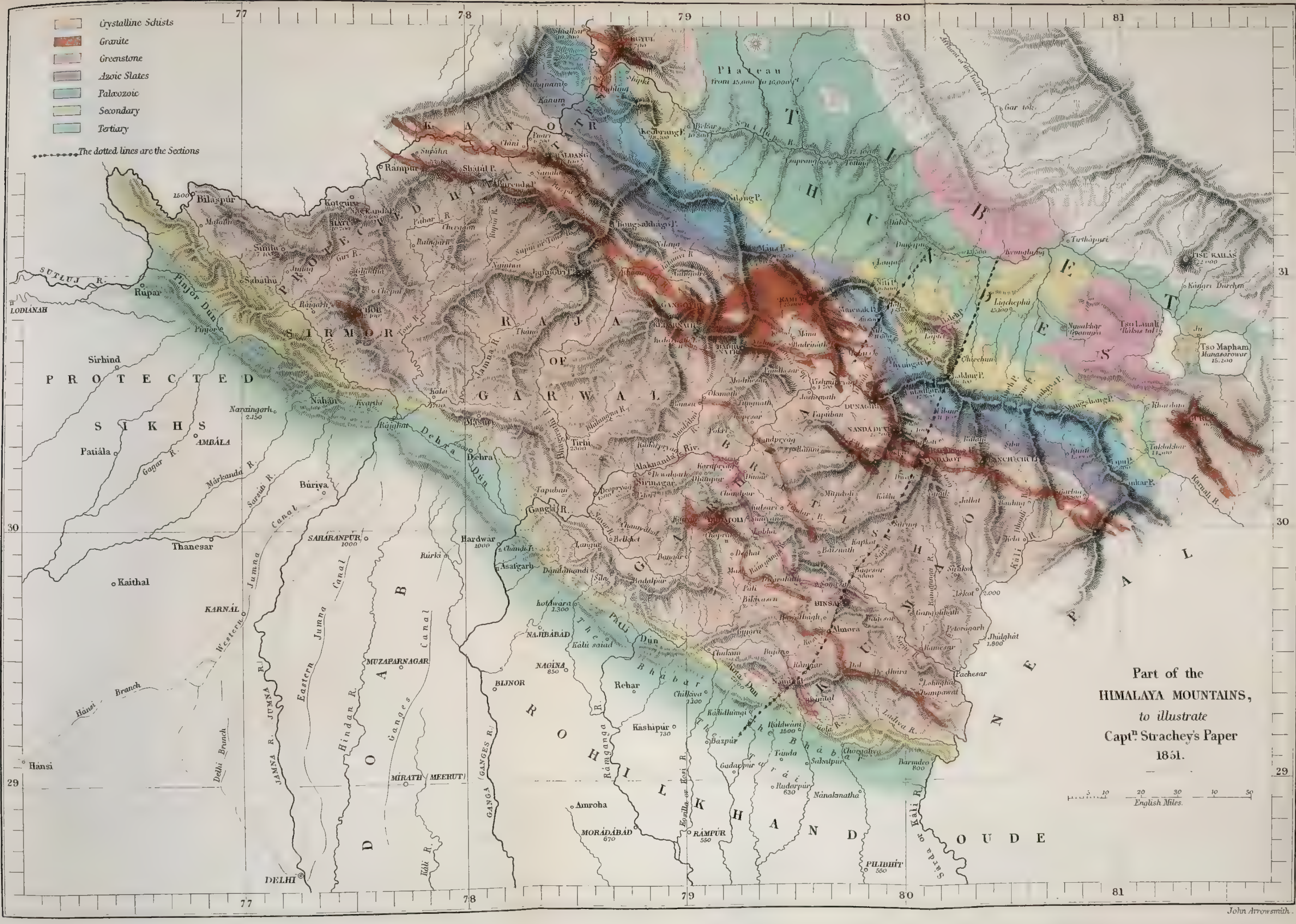
[Pl. XVI. XVII.]

It is, I think, to Humboldt that we are indebted for the first correct views of the general configuration of the surface of the central portion of the great continent of Asia, and for the announcement that, while the greater proportion of the area is comparatively low, the high lands are confined within somewhat narrow limits.

The elevated region is known to extend through nearly 30 degrees of longitude, from the sources of the Oxus to those of the Hoang-ho, the Yellow River of China. Its southern limits are tolerably well known also, but we almost entirely depend upon Chinese geographers for the information that we possess of its extension to the north. The chain of mountains that, under the name of Himalaya, forms the northern boundary of Hindostan, is in reality the southern face of this great mass of elevated land, while its northern face in like manner appears upon our maps as the range called Kouenlun. To the south lie the plains of India, whose greatest elevation is not more



Part of the
HIMALAYA MOUNTAINS,
to illustrate
Captn. Strachey's Paper
1851.



John Arrowsmith.

than 1200 feet above the sea; while on the north the countries around Yarkund and Khoten appear to form an equally striking plateau, which, as we may safely conclude, from the nature of its vegetable productions, can hardly exceed in altitude 3000 feet. The loftiest summits known on the surface of the earth are to be found towards the southern edge of this elevated region, more than one peak having been measured whose height is upwards of 28,000 feet, while along the whole line peaks of 20,000 feet abound.

So little is known of the interior and northern parts of this region' that it is impossible to offer any general account of it based upon actual observation; but as far as we may judge from those parts that have been explored, it appears that the surface is, with few exceptions, broken up into a mass of mountains, the general elevation of which, valleys as well as ridges, is very great; and to the best of my judgement there is no reason for supposing that either the Himalaya or Kouenlun have any definite special existence as mountain-ranges apart from the general elevated mass of which, as I before said, they appear to be the two opposite faces.

From the point where the Indus enters the plains of the Punjab to that where the Brahmapootra enters Assam, the Himalaya extends without interruption over a distance of about 1500 miles. Its direction appears to change gradually from north-west and south-east on the west to nearly due west and east on the east, so that the mountains form on the whole a curve, the convexity of which is turned to the south-west.

The portion of the chain to which I am about to allude more particularly is somewhat to the west of the centre of this line; it lies a hundred or a hundred and fifty miles to the north-east of Agra and Delhi, the two chief cities of north-western India, on about the 30th degree of north latitude and the 80th of east longitude, which meridian will be seen to pass through the island of Ceylon, and not far from Cape Comorin, the extreme southern point of the peninsula of India. The district in question (see Map, Pl. XVI.) is immediately contiguous to the western boundary of Nepal, and lies between the river Káli, a tributary of the Ganges, separating it from Nepal, and the river Sutluj, which is the most eastern of the feeders of the Indus. The principal stream of the Ganges flows nearly midway between the other two rivers. Simla and Sabathú are within this region, not far from the Sutluj. Cashmere is beyond it to the north-west, from 200 to 300 miles; while Sikim, from which Dr. Hooker has lately returned, is situated about 500 miles further east, and nearly north of Calcutta.

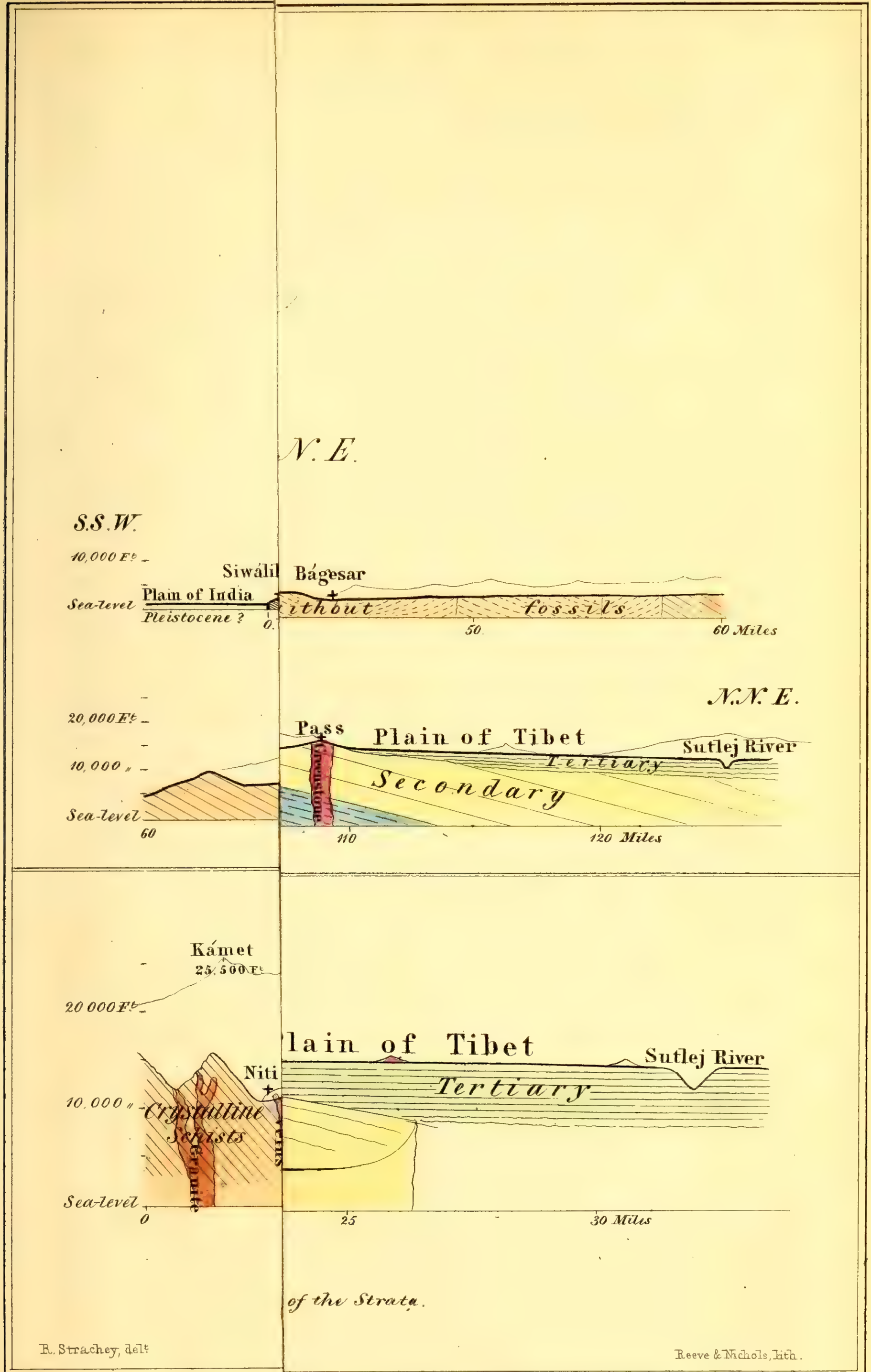
The distance between the points where the Káli and Sutluj leave the foot of the mountains is about 200 miles, while the breadth of the tract of which we shall have cognizance, measuring from the termination of the Plains of India in a north-westerly direction, is nearly 120 miles. Of this again it is only the eastern half that I have myself visited, and I am dependent on the published accounts of Capt. Herbert and M. Jacquemont for the very imperfect knowledge that I have of the country to the west of the Ganges. When we consider the great extent of this region, the natural difficulties which so rugged a country presents, and the very short period that I was able to devote to its examination, it will at once be apparent that all I can have to offer is a mere sketch of its more striking geological features, and this I shall endeavour to give as briefly as possible.

It is right, however, that I should first mention, that a considerable quantity of the geological information embodied in this paper and my map is derived from the observations of my brother, Mr. John Strachey, of the Bengal Civil Service, who has resided for several years in this part of the mountains; further, that my own investigations were made during the years 1848 and 1849, while I was employed by the Indian Government in scientific researches of a miscellaneous nature in the same districts. I am bound to add, that it is altogether to Mr. Thomason, the present Lieut.-Governor of the north-western provinces of Bengal, that I am indebted for my employment in this manner.

Along the whole of the southern face of the Himalaya, from the debouche of the Indus to that of the Brahmapootra, extends a vast unbroken plain, which is prolonged southward to the Bay of Bengal, near Calcutta, on the one hand, while on the other it follows the Indus through the Punjab and Scinde to the Arabian Sea, covering in all an area of nearly 500,000 square miles. The highest portion of this plain is that between the rivers Sutluj and Jumna (see Map), and its elevation along the foot of the mountains is here probably about 1200 feet above the sea. On either side of this the drainage of the country flows in opposite directions, falling, as the case may be, either into the Ganges or the Indus, while the level of the surface, as might be supposed, gradually declines as we approach the sea.

That all of this is a sea-deposit there can be little doubt, although the direct proof, by the discovery of marine shells, is still wanting. Strong grounds for such a belief are, however, afforded by the extreme evenness of the surface and regularity of its slope, as well as by the nature of the soil, which everywhere, excepting in the immediate vicinity of the mountains, is a deposit of the most finely-comminuted matter; so that it is really no exaggeration to say that one might go from the Bay of Bengal, up the Ganges into the Punjab, and thence return to the sea by the Indus, passing over upwards of 2000 miles of ground, without seeing a pebble however small. The saltness of the wells in the desert tract which extends along the Indus to within fifty miles of the foot of the mountains seems also to point to the same conclusion. Marine deposits, when raised from below the surface of the ocean so as to form dry land, must of necessity contain a considerable quantity of the salts found in sea-water; and when, as is here the case, there are no rivers and no rain, by means of which they may be dissolved and washed out, we may naturally expect to find the water of wells in such strata to be salt.

Close along the foot of the mountains we find the soil to be everywhere composed of deposits of boulders and gravel, which become rapidly less abundant as we advance into the plains, and are, I believe, quite lost sight of within a distance of thirty miles from the outer hills.



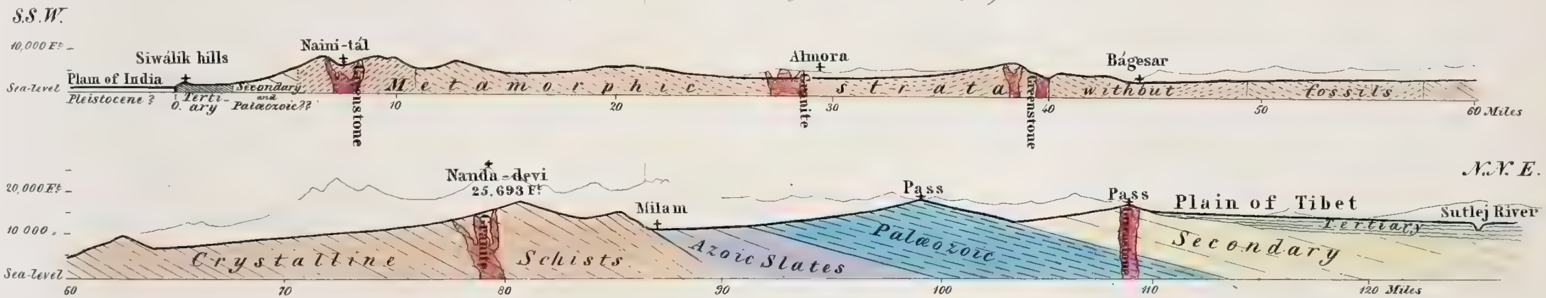
R. Strachey, delt

Reeve & Nichols, lith.

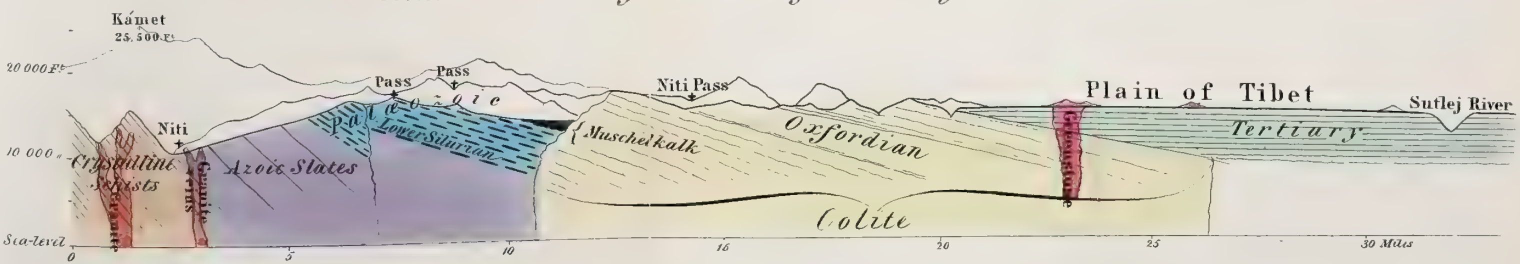
Geological Sections of the Himalaya and Tibet

No. 1.
Section of the Himalaya Mountains. From S.S.W. to N.N.E.

(The same Scale is used for Heights and Lengths.)



No. 2.
Section of the Fossiliferous Strata of the Himalaya and Tibet.



N.B. The parallel lines drawn through the different formations shew the dip of the Strata.

R. Strachey, delt.

Reeve & Nichols, lith.

I have nowhere seen anything having the appearance of an ancient beach or sea-margin along the edge of this plain, which may probably be accounted for by the extreme violence of the rains, which is always greatest over the first slope of the mountains. On one occasion I myself measured a fall of one inch of rain in about twenty minutes; this was at Hardwar, where the Ganges leaves the outer hills.

In proceeding with my explanation of the geology of these mountains, it will, I think, be desirable that I should follow with a certain amount of detail some one particular line of section, rather than attempt to give a general account of the whole country. I shall in this manner be better able to distinguish between what is matter of actual observation and what of speculation. The line that I shall take for this purpose (passing S.S.W.–N.N.E. between 79° and 80° 30′ E. long., see Map, Pl. XVI.) is selected only because it is best known to me, and not that it appears to exhibit a normal state of things better than any other: too much stress, therefore, must not be laid on its details, and it consequently seems desirable that as I proceed I should point out such generalizations as seem to me to be borne out by the observed facts.

I may also here mention, that the direction of the strike of the strata is usually not far from that of the chain generally, and in this particular portion of it W.N.W. to E.S.E.; also, that the line of section that I shall follow is on the whole nearly perpendicular to the strike.

The transition from the plains to the mountains is sudden and well-defined. A line of hills, called the Siwalik or Sub-Himalaya Range, and well-known to geologists by the striking palæontological discoveries made there by Dr. Falconer and Colonel Cautley, rises abruptly and without any intermediate undulating ground from the apparently perfectly level surface of the flat country. The deposits of which these hills are formed seem to be sandstones, often quite unconsolidated and generally very soft, marls and clays, and boulders and gravel-beds sometimes forming conglomerates. The dip of the strata is usually towards the general mass of the mountains, on my particular section being N.N.E., at an angle of 5° or under (see Section No. 1, Pl. XVII.). A steep face, from which rise the highest summits of this range, is thus turned towards the plains, while a long gentle declivity slopes inwards and forms a shallow valley along the general line of strike, by meeting the foot of the next line of hills which runs on the whole parallel to the outer line, but from five to ten miles further in. This longitudinal depression is, as may be supposed, by no means continuous, but is broken up in some places by the passage of the streams that drain the interior of the mountains, in others by the confluence of the two ranges of hills that usually form distinct lines. The lower parts of these valleys generally appear to be covered with a deposit of boulders and gravel, that slopes somewhat steeply from the great mass of mountains towards the outer range of hills, so that the whole of the bottom of the valley is considerably raised above the level of the plain without. The drainage of these valleys usually collects along their longitudinal axis, and either falls into some of the larger streams that cross them, or less frequently, by a sudden bend to the south, finds an exit for itself into the plains. These valleys are, in the country with which I am acquainted, termed Dún, while in Nepal, according to Mr. Hodgson, they are called Mári.

I may here mention, that with these valleys has been confounded by some writers a totally distinct tract, locally called Tarai or Tariyani. Along the southern edge of the outer hills extends a band of ten miles or so in breadth, usually covered by forest, and remarkable for its utter want of water. All the minor streams as they leave the foot of the hills are rapidly absorbed and disappear in the sandy and shingly deposits that there prevail, and wells have to be sunk to a great depth before water can be met with. The surface-slope of this absorbent band is very considerable near the hills, but rapidly diminishes as we recede from them; and we usually find that at a distance of from ten to fifteen miles the character of the country changes rather suddenly, the extreme dryness of the forest-belt being succeeded by a line of swamp, clothed by a thick growth of reeds and grasses; this is the Tarai. It has been usually supposed that this swampy tract was formed by an actual depression in the general surface of the country; but this seems to be altogether an erroneous idea, the truth being that along this line the drainage of the higher country beyond breaks out in copious springs which collect into swamps, in some small degree, perhaps, from artificial obstructions to their outflow for the purpose of utilizing the water for irrigation, but chiefly, I conceive, from the small slope of the country, which can only amount to a few inches in the mile for a distance of many hundred miles from the sea. We accordingly see that this peculiar feature of the plains immediately along the outer hills is confined to the country to the east of the Ganges, the general level of which is considerably lower than that to the west of that river. The dry band of country is, I presume, a great talus of coarser matter that has been formed along a former line of coast, covering a deposit of finer and less permeable silt, just as appears to be usual now; the surface of the former being naturally more inclined, of the latter almost horizontal, and the drainage of the whole of the upper portion being brought to the surface along the line of union of the two.

The Siwalik Hills seem, with hardly any exception, to have a well-defined existence along the whole of the chain, from the Sutluj to the meridian of Calcutta, running in a tolerably regular line, and presenting much the same general features close along the southern edge of the general mass of mountains. It so happens, however, that at the particular place where my examination took place, these hills are exceedingly ill developed; and as I could nowhere find or hear of any fossil remains among them, I did not think it worth while to devote so much of my already very limited time as would have been necessary for such a purpose to an attempt to unravel their obscurities, which after all would most probably have been unavailing. I am consequently unable to offer any fresh information as to the age of these strata which have hitherto been supposed to belong to the Miocene Period.

Associated, in some manner that I am unable to explain, with these outer hills we find, as we advance into the mountains, other beds chiefly consisting of light-coloured sandstones, often containing small seams of lignite and imperfect vegetable impressions, often associated with marls and gypsum, and sometimes with salt springs. So far as I have been able to form an opinion, these beds seem to occur immediately along the foot of the great mountains, of which at first sight they appear to form a part, in a position intermediate between them and the outer or Siwalik hills, and forming indeed the northern boundary of the longitudinal valleys I have been describing. These strata contain no other fossils that I have heard of, excepting the vegetable impressions just mentioned. They all dip to the N.N.E. at a low angle, thus appearing to overlie the Tertiary beds of the outer hills and to go below the mass of mountains to the north of them (see Section No. 1). The obscurity of all this is increased not a little by the discovery of what I believe to be the impression of a large Trilobite in a locality on the southern face of the mountains, not far from the place where these sandstones end, and apparently superimposed on them. This fossil has unluckily been mislaid, but I hope to be able to get it again. On the whole, however, I think it appears most probable that there must be a series of great faults along the southern edge of the mountains, by which these confused appearances are produced. As to the inner line of sandstones, it has been surmised, entirely however from their mineral character, that they are of the Saliferous age, and that they may possibly be the extension of the strata containing rock-salt which we find on the same general line further to the west in the Punjab; it is also possible that they may have some connexion with the fossiliferous strata said to occur near Sabathú*.

The whole of these deposits, including the outer hills, seem to have a much more considerable development as we proceed from the Ganges westward, both as to altitude and breadth of exposure at the surface (see Map). Thus the outer hills, which in the proximity of my line of section hardly exceed 100 or 200 feet in elevation, reach a height of 3000 feet between the Ganges and Jumna, and I believe as much as 6000 feet to the west of the latter river. The horizontal extent occupied likewise appears to increase in a similar manner. It is then, I think, to a careful examination of the outer ranges of hills in the northern part of our newly-acquired territories in the Punjab that we may look for the solution of the obscurities that now involve the relations of all these beds, and investigations are, I believe, now going on there from which we may hope to obtain much valuable information.

As we advance along the line of section to the northward we find that we have now entered the great mountain-region, which continues without a break for a distance of nearly 500 miles. The exterior portion of this rises somewhat suddenly to an average elevation of upwards of 7000 feet, the highest summits exceeding 8500 feet in altitude. It consists of a mass of argillaceous schists, grits, and limestones,

* See Major Vicary's Paper on the Upper Punjaub, Quart. Journ. Geol. Soc. vol. vii. pp. 45, 46.

intersected by one or more lines of igneous action (see Map). The schists sometimes have a true slaty fracture, the grits pass into quartzites, and the limestones are for the most part exceedingly hard and compact, and of a dark colour; the whole being entirely devoid of fossil remains. The stratification of the beds is perfectly clear, the dip being in general to the N.N.E., at an angle of from 10° to 15°. On the line of section, however, a portion of the mountain is crossed where we find the dip to be suddenly reversed, so as to take the direction of S.S.W. (see Section No. 1). This reversal of the dip is of rather frequent occurrence in the mountains generally, and seems to be without doubt the result of the absolute rupture and dislocation of an immense mass of the strata, in this case five or six miles square.

The lines of igneous action on the whole follow that of the strike. Although greenstone may be taken as the prevailing type of the eruptive rock, there are very great varieties in its composition. In some places it is crystalline, and then sometimes assumes the spheroidal form; in others it has an almost homogeneous granular texture. At one place it passes into a syenitic rock, at another into a granite. From being undoubtedly crystalline and amorphous, it gradually takes a decidedly laminated structure, having the aspect of an earthy or uncrystalline gneiss. At one point, a little to the east of the section, an outburst of considerable extent, chiefly of an amygdaloidal form, is associated with the formation of several small lakes, at elevations of between 3000 and 4000 feet. Not far from these is another small lake, called Naini-tál, which gives its name to a sanitary settlement that has been founded on its edge. In the immediate vicinity of this lake, the elevation of which is about 6400 feet, are dykes of a well-defined crystalline greenstone, one of which reaches to the summit of the ridge above the lake to an altitude of upwards of 7000 feet. A similar greenstone is met with in several places at equal elevations on the more southern face of this group of mountains. The line of igneous action is elsewhere seen to enter the sandstone region last described. The eruptive rock then takes the form of a granite, which in some places becomes of a dark green colour by the mixture of what appears to be chlorite in considerable quantities. I could not see any actual contact of this granite with the strata in its neighbourhood, but the sandstone is seen within a very few yards of it quite unchanged; and such appears to be the case with all this series of eruptive rocks, their effect invariably seeming to be confined to shattering the strata and rendering them rather more subject to decay than usual. On one part of the line rich mines of red hæmatite are found and worked in quartz-rock close to the trap.

Although the evidence is confessedly defective, I yet think that there seems reason to suppose that an assemblage of schists and limestones of a semicrystalline character, associated with eruptive rocks of the greenstone order, such as I have here been describing, is not a merely local phænomenon, but that these rocks are always found along the southern edge of the mountains immediately succeeding the sandstone-ranges. To the east of the Káli I have no information whatever, but from that river to the Jumna we have sufficient evidence of the truth of my inference. Proceeding far to the west, to Cashmere, we again find that the exterior line of mountains, that rises immediately over the sandstones, is constituted of the same rocks, although the elevation they attain is there so great (viz. 13,000 or 14,000 feet) as to bring them almost within the range of perpetual snow. An amygdaloidal greenstone, of which I myself happen to have seen specimens, is found on the summit of these mountains at the Drás pass, and the schists with which it is seen are described by Jacquemont as being identical with those of the exterior range between the Ganges and Jumna, which again are, as I have already observed, altogether similar to those of the more eastern parts of the line.

Following the line of my section, we next enter a tract of considerable breadth, the main rock of which is a mica-schist of a not very crystalline order, and which generally disintegrates readily. Its dip is throughout to N.N.E. at a moderate angle. Along the central part of this region runs a line of granite, that extends with hardly any interruption from the Káli to the Ganges (see Map), near which river it seems to end in a large outburst in a mass of mountain, the elevation of which reaches 10,300 feet. The ordinary summits along the line are not however more than 7000 feet in altitude. This granite nowhere appears to produce any particular disturbance of the strata on a large scale; the dip remaining at much the same angle, and constantly to the N.N.E., on both sides of the granite. The granite is often porphyritic, and it maintains this character, as well as that of being much subject to decay, throughout its whole extent. In one place I have seen veins in its vicinity penetrating the mica-schist, and accompanied by considerable contortions of the strata. The vein-granite is much more coarsely grained and more felspathic than that of the great outburst. Near the edges of the granite, fragments of mica-schist showing a distinctly laminated structure are not uncommonly found imbedded in it. At one place, at its edge, was also seen an outburst of syenitic greenstone, in the form of a dyke, the exterior of which was amorphous and earthy, while the central portion was highly crystalline, of a very black colour, and assumed the spheroidal structure.

The imperfect nature of our information does not enable me to trace this line of granite with certainty to the west of the Ganges, but it is highly probable that the granite of the Chor mountain, the summit of which reaches a height of 12,000 feet, may be a continuation of this same outburst.

Throughout these schists garnets are very frequently found of every size, from an inch in diameter and downwards. Veins of schorl, with small quantities of felspar, are also common. Limestone is very rare in this tract, and I only know of one small bed, which is very crystalline. Graphite occurs in the mica-schist in the vicinity of Almora, the chief town of our hill-districts, both in an impure form disseminated in the schist, and in small nodules apparently quite pure. A very remarkable band of rock, apparently interstratified with the mica-schists, and of such a nature that it is not easy to decide whether it be eruptive or merely metamorphosed, although on the whole the latter is the more probable, has been traced across this part of the country in the direction of the strike for upwards of thirty miles, maintaining its peculiar characters unchanged, although the beds of which it consists are only a few inches in thickness.

As we approach the northern edge of this region of mica-schist, we perceive that the dip gradually changes from N.N.E. to S.S.W. (see Section No. 1). This change of dip is, so far as the country has been examined, continuous from the Káli to the Ganges, following the general line of strike, although the change is not always gradual, as on my section. The reappearance of some graphite-beds on opposite sides of the synclinal axis on the line of section gives us grounds for supposing that this belt of strata, dipping to the south, is the continuation of those dipping to the north immediately adjoining them.

Although I have thus far spoken of this tract as consisting of mica-schist, which indeed is the case on the line of my section, we shall find that to the west there is a considerable development of quartzose rocks (to the south of the granite), which gradually pass into a decided mica-schist and gneiss as they approximate to the granite. The same is true of the rocks to the north of the line of granite on the east, and we further observe that the schists in the whole of this tract are usually very quartzose. It seems, therefore, highly probable, that the mica-schists of this belt of the mountains have been produced by the action of the granite on quartzose beds that previously to the eruption occupied the whole space.

On passing the northern edge of this tract of mica-schist we find a decided dislocation of the strata (see Section No. 1), following the line of strike generally, and we come upon a set of rocks of a totally different character, which, however, maintain a great similarity *inter se* along the line of change. This line is likewise followed by a line of eruptive action, which is possibly connected with the tilting of the northern edge of the mica-schist tract to the south-west.

This eruptive line (see Map) has been traced, with hardly any break, from the Káli to the Ganges. The rock is for the most part greenstone, but a black basalt also is found in one or two places. The greenstones along this line are frequently seen to pass into decided schists, and the conglomerates and breccias that have been termed "ash" or "volcanic grit" are common. In these conglomerates I have found quartzose pebbles, the exteriors of which are distinctly molten, a nucleus in the centre being left comparatively unchanged; mixed with these are smaller pebbles, which have been acted on quite through; and it is curious to observe quartzose beds in the neighbourhood distinctly stratified with slates, assuming exactly the appearance of these baked pebbles. There seems, therefore, to be sufficient reason to infer that some of these greenstones are contemporaneous with the stratified rocks that accompany them. These are for the most part slates, limestones, and grits or quartzites. The limestones are usually very hard, often associated with steatite in the vicinity of the trap-rocks. Iron and copper likewise follow the line of the eruptive rocks; the iron usually near the eruption, the copper rather further off with the limestone and steatite, and with these is also commonly found a rather remarkable crystalline carbonate of magnesia. The dip of these beds is to the N.N.E., but in the vicinity of the eruptive rocks they are frequently very much disturbed and contorted, and have every appearance of having undergone considerable change from the action of heat.

In proceeding still further northward, similar strata, with large quantities of limestone, continue for many miles. The strike remains the same throughout, but two bands are crossed in which the dip is suddenly reversed from N.N.E. to S.S.W. On one of these lines of dislocation, where the strata are absolutely vertical, is a hydrosulphuretted spring. It issues from a limestone-rock, incrusting the surfaces of the substances in its neighbourhood with minute crystals of sulphur, and depositing a large bed of tufaceous carbonate of lime as it flows onward. Some miles to the east of my section, a similar spring, which is distinctly thermal, may also be seen on the same line of fault; and I have reason to suppose, from what I have heard, that there is another still further to the east, nearly on the same line, at the Káli River.

The schists and limestones generally become talcose along the northern part of this region, and we then pass into the crystalline schists that are invariably found along the line of the great peaks, and this we also find to be a line of granitic eruption. To the west of the section, however, the strata to which I have been alluding are for the most part converted into highly-crystalline schists, apparently by the intrusion of two lines of granite, the more northern being a branch of the granite of the snowy peaks, while the other, which is further south, has a mineral character peculiar to itself, although it still follows in general the line of strike.

Entering the region of the crystalline schists of the great line of peaks, we find the strike still remaining the same, with the dip pretty constantly to the N.N.E. (see Section No. 1). Along the lines on which the points of greatest elevation are found in this part of the range, we invariably see for a breadth of several miles veins of granite in great abundance penetrating the schists, often cutting through them, but perhaps most frequently following the bedding of the strata, between which they seem to have been forced. The great peaks are, I think, in almost every case composed of schistose rock, but the granite-veins may be most clearly seen on the faces of the mountains to very great elevations. Kamet, one of the highest of the peaks in this region, seems, however, to be among the exceptions to this rule; its summit, which is upwards of 25,500 feet above the sea, appearing to consist of granite alone. This line of granite seems to be subdivided into several branches, distributed generally along the strike, but otherwise not very regularly (see Map). It appears to consist, where I have seen it, almost entirely of veins of moderate size, and such is probably its general character in the portion of the mountains between the Sutluj and Káli; but the veins occasionally expand into masses of considerable magnitude; and more rarely large outbursts are met with that constitute whole mountains. In the vicinity of the peak to which I have just alluded, Kamet, the granite-area is very large (see Map), and a similar development of it also occurs in the vicinity of Gangotri, at the source of the sacred branch of the Ganges. The vein-granite is usually large-grained, with schorl-crystals. It is very hard and durable, neither it nor the schists that accompany it being at all liable to decay. The felspar of all the granites that I have seen in these mountains is white, and kyanite is of frequent occurrence in the veins.

The schists that accompany this granite are very hard and crystalline, and comprise all varieties of mica-schist and gneiss. Beds of highly crystalline limestones, some pure, others hardly to be distinguished by sight from mica-schist, are of frequent occurrence, and a band of such rocks seems to traverse the country near the line of greatest elevation. The strata, where penetrated by the granite, are often very much contorted, and the dip appears on the whole to increase as we approach the granite, where it reaches an angle of 45°, which it does not often exceed. Thermal springs are met with in many of the valleys along the line of granite, and in several that I am acquainted with the temperature seemed pretty regularly to be about 128° Fahr.

The whole of the appearances presented by the granite and crystalline schists of the great line of peaks in this part of the mountains seem to be universally repeated throughout the whole length of the chain when we reach the region of maximum elevation; and, as we extend our examination, we still continue to find additional reasons for concluding that the general geological phænomena of the range, and the causes that have produced them, remain very similar over great distances.

The line of section that I have selected to illustrate the geology of the upper parts of these mountains is taken a little to the west of the lower part of the line, through the country that I have examined the best, in the neighbourhood of Niti (see Section No. 2, and Map).

In immediate succession to the crystalline schists penetrated by granite-veins, we here come at once upon slaty beds overlying them, along the bottom of which, near the mica-schists and gneiss, is a line of granite-veins differing somewhat in appearance from those of the larger eruption, and not producing any great alteration in the slaty beds themselves, as is shown by the occurrence of a coarse conglomerate, the component parts of which are perfectly distinct, only a few feet above the granite. Sufficient change, however, has taken place to prevent our distinguishing much more than that the constituents of this rock are chiefly quartzose, and that it contains rounded stones of all sizes. I have met with this conglomerate in a similar position and with much the same general appearance thirty miles or so further to the east.

Above these are slaty beds, in all perhaps 9000 feet in thickness, consisting of coarse slates, grits, and limestones, all more or less affected by slaty cleavage, and all devoid of fossil remains.

It is after reaching the top of these strata, which is rarely done at a less elevation than 14,000 feet above the sea, that we at length enter again a region of fossiliferous rocks, which extends as far as my examinations have been carried. And it is not a little wonderful to find at this immense elevation a regular succession of most of the more important formations, from the Silurian to the Tertiary Periods.

The Palæozoic beds, met with immediately above the slaty rocks I have just mentioned, seem to have a thickness of about 6000 feet, but it is quite possible that organic remains may extend lower than I supposed; indeed, from the very difficult nature of the country, the precise thickness of the deposits and the limits of the different formations cannot be determined properly without a much more careful examination of the country than I was able to give it.

The lower portion of these strata are undoubtedly of Silurian age, and I am indebted to Mr. Salter for the following list of the species that he has been able to recognize on a somewhat cursory examination of my specimens.

Among the Trilobites are—*Cheirurus* (the Silurian form of the genus), *Lichas, Asaphus* (only as yet found in Lower Silurian beds), *Cybele, Illænus.*

Of Molluscs are—*Strophomena,* a strongly ribbed *Orthis, Terebratula, Leptæna* very like *L. depressa, Lingula, Orthoceras, Cyrtoceras,* and *Lituites.*

Of Polyps—*Favosites, Ptilodictyon, Chætetes.*

Also *Encrinites* and *Cystideæ*; *Tentaculites* and other Annelids, and Fucoids.

I was likewise fortunate enough to have an opportunity of showing these fossils to M. Barrande, who appeared to have little doubt, from their general character, that some of the beds from which they came were certainly of Lower Silurian age.

The lowest beds of these Palæozoic strata consist of dark-coloured thick-bedded limestones, in some places filled with Corals. These, however, I have not yet had an opportunity of having examined. They are succeeded by limestones mixed with slates, in which were found the strong-ribbed *Orthis, Terebratula, Lingula,* a large Univalve, and fragments of *Encrinites.* Above these come flaggy limestones with grits, that contain the greater part of the *Trilobites, Strophomena, Leptæna, Lituites, Ptilodictyon, Cystideæ,* and Fucoids. The beds then become more argillaceous, and shales and slates mixed with an impure concretionary limestone follow. In these beds are found *Cyrtoceras* and *Orthoceras,* and amongst the nodular concretions of limestone a *Chætetes* is common. Next in order come dark-red grits, sometimes marly, containing only a few fragments of Encrinital stems. Above these, pale flesh-coloured quartzite, and finally a white quartzite, in neither of which I ever found any fossils, and which form the highest peaks of the ridges composed of the Palæozoic rocks.

The whole of these strata are in various degrees affected by cleavage and joints, which penetrate all the beds without regard to their mineral character, although in a somewhat less-marked degree in the limestones and quartzites.

That the general sequence of these strata is pretty regularly maintained, I have seen over a longitudinal extent of about fifty miles, but it appears highly probable that their development has a far greater range, as we shall also see to be the case with some of the other groups of the fossiliferous rocks.

From an examination of M. Jacquemont's account of his geological researches in the upper parts of Kunawur, I think it almost certain that he must have found Silurian fossils, as well as others of the newer formations which I shall presently mention, and I hope, if these are still preserved at Paris, to have an opportunity of seeing them before long.

Before passing on, I must observe the very remarkable similarity of general mineral appearance that subsists between the Silurian rocks of the Himalaya and of this country. The peculiar pale tint assumed by many of these rocks answers most exactly to the descriptions given by Sir Roderick Murchison of the Silurian districts of Wales, and the characters of the concretionary limestones of both countries appear equally to correspond. Even in hand-specimens the texture and appearance of the rocks and of the fossil impressions are so similar that they might most readily be mistaken one for the other. In pointing to these resemblances, however, I would not have it supposed that I should wish in any way to set up mineral character as a criterion by which to decide on the age of any rock. Nevertheless, the facts, if they are to be relied upon, would appear to indicate that as we see the conditions of the existence of organic matter to have been generally similar over large areas, or even over the whole earth, during the same epoch, and to have changed with the progress of time, so likewise has it been with the conditions under which the mineral constituents of the earth have been aggregated.

The Palæozoic strata that I had an opportunity of examining in detail *in situ*, which I have just been describing, appear to be exclusively Silurian, but the existence of rocks of Devonian or Carboniferous age seems to be shown by one of my specimens, a fragment not found *in situ*, which contains a *Productus*. I may here be allowed to repeat that, the higher portions of the Silurian rocks being usually found at elevations of 17,000 or 18,000 feet, their examination is not a very easy task, and the difficulties occasioned by the great altitude are infinitely aggravated by the confusion into which the beds are thrown by the vast dislocations that have accompanied the elevation of these mountains.

In concluding my remarks on the Palæozoic beds I would observe, that as a general rule, to which, however, there are no doubt many exceptions, these rocks are to be found forming the summits of the highest Passes between the British provinces of Kumaon and Garhwal and Tibet, which probably average 18,000 feet in elevation, and that the highest points of the ridges on which these Passes are found not unfrequently reach nearly 20,000 feet in altitude (see Section No. 2).

In proceeding along the section, we shall next observe some beds very remarkable from their apparently close similarity to the Muschelkalk of Europe. I can now only regret, that, not having been sufficiently aware of their importance, their exact relation to the beds below them has not been better made out; but their position in the series immediately above the Palæozoic rocks is at least certain. In one place these strata were found *in situ* intermediate between the Palæozoic and Secondary rocks, but the greater part of my specimens were obtained from fragments lying on the north slope of the Palæozoic ridge, which, as may be seen from my section, No. 2, Pl. XVII., appears to terminate with a line of fault, to the north of which a cliff of Oolitic age suddenly rises. It is therefore probable that they were either the *disjecta membra* of some of the strata broken up in the upheaval of the great mountain above them, or that the beds from which they have been derived are immediately below them, covered up by the vegetation that clothes the slope of the valley.

From these strata I have obtained not less than twenty-five species of fossil shells, which is a remarkable circumstance considering the small bulk of the specimens that I was able to bring away with me.

Mr. Salter, who has been so good as to examine these also, tells me that we have *Ceratites, Goniatites, Ammonites, Spirifer, Pecten, Terebratula, Chonetes?, Pholadomya.*

The Muschelkalk-beds were chiefly dark-coloured limestones, and, where seen *in situ*, were associated with shales and dark-red grits, the latter of which seemed very similar to those found near the top of the Palæozoic series. The line on which they were seen was, however, a very bad one for determining such matters, for it was in one of the great valleys, and consequently on a great dislocation where accumulations of debris almost always greatly predominate over rock *in situ*.

In our progress northward, we next come upon the strata that form the representatives of the Jurassic group. As in the Palæozoic beds, so we here find the general dip to be to the north; but it is impossible for me to offer any opinion as to the degree of conformability of any of these deposits one to another, owing to the great disturbances to which they have everywhere been subjected. It appeared to me, however, as probable that, in the parts of the mountains that I examined, a great line of fault intervened between the Oolitic and Palæozoic series. The mountain-ridge of Silurian age most carefully examined by me lies generally parallel to the line of strike, and along its north-east face runs a stream separating it from the Secondary rocks which rise in an almost impassable precipice beyond. The section here exposed must be at least 5000 or 6000 feet in thickness, but the difficulties of the route prevented my extending my examination into the lower beds. The lowest that I reached were of black limestones and shales, with very few organic remains, and those very imperfect. Above these lie several thousand feet of limestones of various descriptions, the rock in some places being almost made up of fragments of shells. Prof. Forbes, who has kindly looked over my specimens from these beds, is inclined to identify some of the species with certain forms that occur in the Fuller's Earth and Cornbrash of England; and it appears that there is here no representative of the Lias.

Continuing to ascend in the series, we reach next a large development of dark-coloured shales which abound with remains of *Ammonites* and *Belemnites*, the former usually imbedded in spherical nodules, apparently of much the same nature as the shale itself, but exceedingly compact. The shale is for the most part on the other hand very rotten, and the band of country along which it is found is often depressed so as to form a valley, apparently in consequence of this disintegration of the rock. This shale Prof. Forbes pronounces to be without doubt of the age of the Oxford Clay, a conclusion indicated by the peculiar forms of the *Ammonites*, several of which seem to be identical with species found in beds of the same age in Cutch and Scinde, which have been figured and described in the Transact. Geol. Soc.*

The existence of these beds in the northern parts of the Himalaya was pointed out by Sir Roderick Murchison some years ago, as proved by the occurrence of some of these *Ammonites* which he had seen. There is indeed direct evidence of the existence of these Oxford Clay strata for a distance of about 200 miles to the westward of the places where I have myself seen them, and their prolongation along the north of the mountains for 200 miles more in an easterly direction is rendered highly probable by the well-attested recurrence of the *Ammonites* in the eastern parts of the kingdom of Nepal.

Although we find stratified deposits apparently lying conformably on the Oxfordian strata, I cannot say anything definite regarding them, as they appear to be almost entirely devoid of fossils. They are very hard and compact, consisting of grits, shales, and limestones, and have not improbably been converted into their present state by the action of eruptive rocks, which are of common occurrence in this region.

But the most striking feature of the geology of these mountains is probably that which I have next to mention, viz. the existence of a great Tertiary deposit at an elevation of from 14,000 to 16,000 feet above the sea, still preserving an almost perfectly horizontal surface. On crossing the water-shed-ridge between the streams that flow to the south into the Ganges, and those that fall into the upper part of the Sutluj to the north, which here constitutes the boundary between the British territory and Tibet (see Map), we find ourselves on a plain 120 miles in length and varying from 15 to 60 miles in breadth, that stretches away in a north-westerly direction. Its western portion is everywhere intersected by stupendous ravines, that of the Sutluj being nearly 3000 feet deep. The sections afforded by these enable us to see that this plain is a deposit of boulders, gravel, clay, and mud of all varieties of fineness, laid out in well-marked beds that run nearly parallel with the surface and that hardly deviate from a horizontal position.

The discovery of the fossilized remains of several of the larger mammalia distinctly marks the Tertiary age of this deposit. The existence of such fossil remains in the northern parts of these mountains had been long known, but we were altogether ignorant of the precise locality whence they came, and had no facts before us from which any conclusions could be formed as to their geological import. The Niti Pass, from which it was said that the bones had been brought, was not the place where they were found, but one of the

* N. Ser. vol. v.

routes only by which they came across the great Himalayan chain from unknown regions beyond.

Mr. Waterhouse, who has been so obliging as to examine the specimens that I procured from these beds, informs me that he recognizes amongst them the following :—

Metacarpal bone and distal end of tibia of Hippotherium ; patella of small Horse ; distal end of radius of a larger species of Horse ; distal half of tibia of a Horse of very large size ; part of metacarpal of a Horse ; upper end of tibia of Bovine Ruminant ; dorsal vertebra of a Ruminant.

Portion of head of an undescribed animal allied to Goat and Sheep, having like them prominent orbits and the horns above the orbits ; but which differs in the peculiar form of the bony core of the horns. The horns are remarkable for being placed very near to each other at the base (their upper portions are broken off). There is a specimen in the British Museum, however, from the same locality, of an animal very like this, in which the horns are seen to be short, stout, and slightly bent outwards at the apex.

Right wing of the atlas vertebra of Rhinoceros ; phalanx of one of the outer hind toes of ditto ? ; and portion of tooth of Elephant ??

Fine suites of specimens of the Bones of Ruminants, Pachydermata, and other animals from this district, presented to the Society by Sir Thomas Colebrooke and Dr. Traill, are in the Museum of the Geological Society, London.

The bones that we have hitherto obtained from these strata are almost all very miserable fragments, so that it is difficult even for the very learned naturalist that I have mentioned to do more than distinguish the genus to which they belong. It is therefore, I am afraid, at present impossible to come to any decided conclusions as to the identity or otherwise of the species here found with those of the Siwalik Hills, a question of the greatest interest with reference to all our speculations on the geology of these mountains. The fossil bones I have not seen *in situ*, nor indeed, curious to say, could I, in spite of every attempt, learn a definite locality in which any one knew positively that they had been found. But of the general position where they occur there can be no doubt, for, besides the common account of their being found in some of the ravines that traverse the plain, on many of the specimens quite enough of the rock in which they are imbedded has remained to enable me to recognize a fine-grained calcareous conglomerate, exactly identical with beds such as I have seen intercalated with the boulder- and gravel-beds that constitute the mass of the deposit. Hills of limestone rise here and there above the general level of the plain, and it appears as though the calcareous matter derived from them had cemented together portions of the sands and gravels that were deposited near them.

The existence of such animals as I have mentioned as being found in these beds being a physical impossibility in the present state of the country, there can be no doubt that the strata have been elevated to their present height from some lower level since the time of their deposition. There is no direct proof that these beds are marine, no shells having been obtained from them; but I think on the whole that the probabilities appear to be in favour of this plain having been a true sea-bottom rather than of having been occupied by a detached body of fresh water. The general extension of some of the older fossiliferous rocks along the northern face of the Himalaya, over a great longitudinal distance, is a fact of which we have tolerable proof, and it thence follows that the line on which they occur, distant about twenty or thirty miles to the north of the great line of peaks, has probably been a sea-margin from the remotest ages of the earth's history until as late as the Oolitic period at least. So far, therefore, there is nothing adverse to my supposition. Nor is the present interruption of the plain any proof that it did not once have a far greater extension. This is sufficiently proved by my having traced these Tertiary beds to the very top of the water-shed-ridge in the vicinity of the Niti Pass, where they reach an elevation of upwards of 17,000 feet; the summit of that Pass being strewn with boulders that appear to be derived from the white quartzite capping the Silurian strata of the neighbourhood. Further, two or three miles to the south of the Pass, a detached portion of this deposit is to be seen on the declivity of the mountain, which must have been separated from the general mass by the dislocations that have upheaved the whole country.

It is moreover to be noticed that there seem to be grounds for supposing that plains, such as I have mentioned, are found in other parts of the chain under somewhat similar circumstances, which may not improbably have once formed portions of the same sea-bottom. The plain of Pamir so long known from the accounts of Marco Polo, and the existence of which is fully corroborated by Lieut. Wood, of the Indian Navy, in his Narrative of his Journey to the Source of the Oxus, may be its representative to the west; while to the east the plains described by Turner as having been passed over during his embassy into Tibet, as well as others mentioned by Kirkpatrick as existing to the north of Nepal, the descriptions of which are quite confirmed by Dr. Hooker, are not improbably of a similar nature.

Another argument in favour of the marine origin of this deposit is, I think, also to be derived from the very regular way in which the beds of gravel and boulders are laid out, for which I should conceive that some action like that of the tides would be requisite.

I have already mentioned the occurrence of eruptive rocks in the Tibetan plateau. A great outburst, in which are found hypersthene and bronzite, besides syenitic and ordinary greenstones, and various varieties of porphyry, occurs in the vicinity of the lakes which are found at the eastern extremity of the plateau (see Map). The greenstone is known to extend considerably to the west, and forms, at an elevation of about 17,600 feet, the summit of Balch, one of the Himalayan Passes into Tibet which I have crossed (see Sections No. 1 and 2).

Having thus given a general description of the geology of this region, I shall as shortly as possible enumerate the chief conclusions to which I have been led with regard to the physical forces that have been called into action in the formation of these mountains.

The general extension of the Chain along the direction of the strike of the strata, is a phænomenon necessarily connected with the action of an upheaving force along a line.

This longitudinal action is further evinced by the parallelism of the lines of *eruptive action* with that of the *strike*.

The continuance of the action of the upheaving forces along the same general line for a vast period of time, with occasional intervals of repose or of subsidence, is indicated along both the north and south faces of the Himalaya. The great depth at which the forces have originated seems to be proved by the regularity of the action along the entire length of the chain, as shown by the elevation of such a ridge as the Siwalik Hills.

The Granites appear to constitute lines of elevation, not of rupture; but there seems to be no specific action produced by them on the dip of the strata, which they appear to leave generally unchanged.

The Greenstones, on the other hand, usually follow lines of dislocation of the strata; being sometimes apparently contemporaneous, and at others intruded through rocks already consolidated.

The cause of the general north-easterly direction of the dip is obscure, although its occasional sudden reversal to south-westerly seems to indicate some connexion with the action of an upheaving force from below, or of violent lateral thrust.

The lines of fracture of the strata are constantly either parallel or perpendicular to the direction of the upheaving force.

The positions of the rivers appear to be altogether dependent on the configuration of surface produced by these fractures; while the configuration of surface, on the other hand, seems to be but slightly affected by the action of the streams, of which there is rarely any visible sign at 200 feet above the present level of the waters, and never to my knowledge above 300 feet.

The fact of the granite of the great snowy peaks being seen in veins, penetrating the schists up to 20,000 feet, makes it highly probable that the granite must have been injected long before the mountains received any considerable development.

That this granite is older than the Silurian period is rendered probable by the comparatively unaltered state of the lower beds of the Azoic slates at the foot of the Palæozoic series, where almost in contact with it.

The conglomerate bed near the bottom of these same Azoic slates shows the proximity of land at the time of its deposit, and indicates that some upheaval of land had already taken place near the present line of great peaks, possibly occasioned by the granite in question.

The occurrence of pebbles of greenstone in the sandstones, supposed to be secondary, along the southern edge of the mountains, shows that the exterior lines of greenstone are older than those beds of sandstone.

The frequent occurrence of boulders of the quartzites, slates, and greenstones of the outer ranges of mountains among the tertiary deposits of the Siwalik Hills, shows that the Tertiary ocean washed the foot of those mountains.

The regular slope of the plains of Northern India up to the Siwalik Hills, which rise suddenly from the flat ground, leads me to infer that the sea must have continued to reach at least as far as the foot of the Siwalik Hills for some time after their upheavement.

The rise of the Tibetan plain has not been caused by the granite eruption of the line of snowy peaks. That the greenstone rocks, that abound in many parts of it, have equally not caused it, is proved by the peculiar nature of the valleys among the hills to the west of the lakes, which must have been laid out level under water; from which it is to be inferred that these eruptive rocks are older than the tertiary beds of the plain. The same thing is shown by the occurrence of worn pebbles of greenstone in the surface of the plain in the vicinity of some of the detached hills of that rock.

The former extension of the glaciers far beyond their present limits is a phænomenon that may be noticed almost everywhere in these mountains, and may give rise at first sight to an idea that there may here also have been some special period of cold corresponding to the glacial epoch of Europe. But it seems, I think, more probable that this is here only the result of a change of climate consequent on the upheaval of the great plains of Northern India.

The existence of ancient moraines on the tertiary plain of Tibet proves that the extension of the glaciers is post-tertiary. Now, if we conceive that after the rising of this plain to nearly its present elevation, the sea still continued to wash the foot of the Siwalik Hills, as I have already said that I considered likely, it is clear that the climate of the Himalaya would have been far more moist, and that the quantity of snow that fell on the highest parts of the mountains would have been greatly in excess of what now falls there, causing a great extension of the glaciers beyond the limits to which they have now receded.

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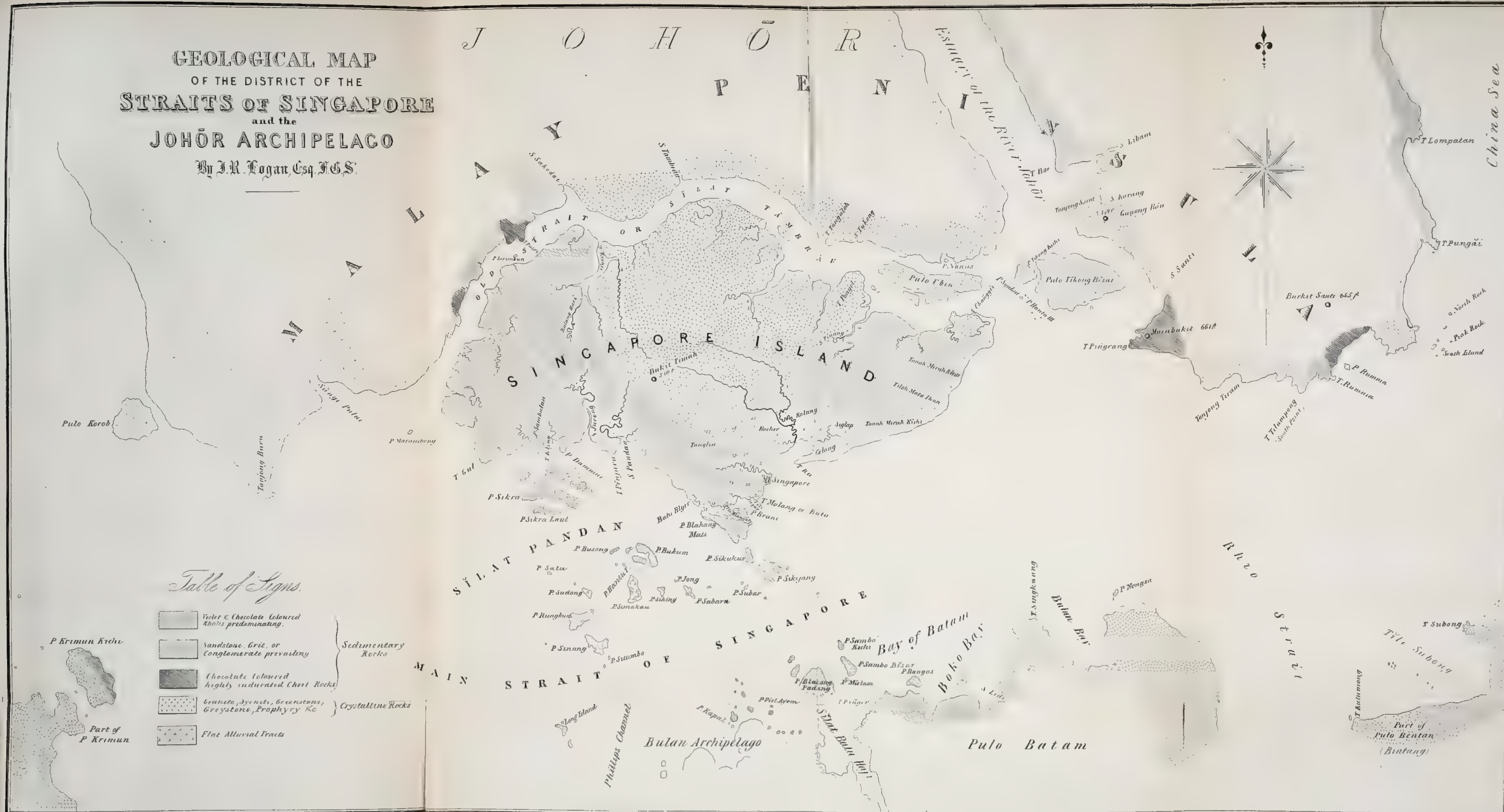
5. Notices *of the* Geology *of the* Straits of Singapore. By J. R. Logan, Esq., F.G.S., M.R. Asiatic S., Corr. M. Ethnological Soc., and Batav. Soc. Arts and Sc.

[Pl. XVIII.]

Introduction.—Under this name I shall describe not only the rocks in the Straits of Singapore and along its shores, but also all those comprehended within a rhomboidal space, about sixty miles long and thirty miles broad, of which the northern boundary is a line stretching E. by N. across the Malay Peninsula, from the Straits of Malacca to the China Sea, and touching the most northerly part of the Old Strait of Singapore; the southern boundary being a line in the same direction, touching the most southerly part of Tīlo' Sumpat, on the north coast of Bintang, and stretching across that island and all those west of it to Phillip's Channel. The investigation of the geology of the Malay Peninsula could not begin at any other place so favourable for observation, for instead of the dense jungle which everywhere else


GEOLOGICAL MAP
OF THE DISTRICT OF THE
STRAITS OF SINGAPORE
and the
JOHŌR ARCHIPELAGO
By J. R. Logan, Esq. F.G.S.
Table of Signs.
Violet & Chocolate Coloured Shales predominating.
Sandstone, Grit, or Conglomerate prevailing
Chocolate Coloured highly indurated Chert Rocks
Sedimentary Rocks
Granite, Syenite, Greenstone, Greystone, Prophyry &c
Crystalline Rocks
Fine Alluvial Tracts
J O H Ō R
P E N I N S U L A
M A L A Y
Estuary of the River Johōr
China Sea
SINGAPORE ISLAND
Bukit Timah
Singapore
Pulo Ubin
Pulo Tikong Bĕsar
OLD STRAIT OR SĔLAT TĔBRAU
SĔLAT PANDAN
MAIN STRAIT OF SINGAPORE
Rhio Strait
Bay of Batam
Boko Bay
Bulan Bay
Bulan Archipelago
Phillips Channel
Sĕlat Bulu
Pulo Batam
Part of Pulo Bĕntan (Bintang)
Pulo Korob
P. Krimun Kechi
Part of P. Krimun
Tanjong Buru
Long Island
T. Lompatan
T. Pungăi
T. Ramunia
Tanjong Tĕram
North Rock
Peak Rock
South Island
Burkit Santi 665 ft
Masubukit 661 ft
T. Pĕngĕrang

obstructs our progress and hides the nature of the ground, the whole breadth of the Peninsula is here depressed and broken up, exposing natural sections in various directions, which are preserved from the obliterating influence of the rapid decomposition and exuberant vegetation of the region by the strong currents which the China Sea, on the E., and the Bay of Bengal, on the W., impel through the depression. Of these littoral sections the best are those of the islets in the Strait of Singapore, and the points of Singapore Island, the S.E. promontory of the Peninsula, Bintang, and Batam, which advance into it, and, receiving the full force of the main current, are worn by more powerful waves than those which invade the sheltered portions of the Straits, such as the narrow channel which separates Singapore from the continent, and the shallow bays of Batam.

I. Structure and Composition of the District.

1. *General configuration.*—The configuration of the district presents several features worthy of remark. The land-portion of it is low, and is composed of hills generally in ramified systems, the direction of the principal branches forming a small angle with that of the geographical axis of the Peninsula (N.W. by N., S.E. by S.), that is, deviating about 20° or 25° to the W. of it, or from N.W. by W. to N.W. by W.½W.* The mean height of the hills must be under 100 feet, the greater number falling short of that elevation, while only a few points attain to heights varying from 500 to 750 feet†. The

* This direction, however, agrees with that of the whole western side at least of Johōr, the Peninsular coast from the latitude of Pulo Lumut, a little to the north of Parcelar Hill, running S.E. by E. to its south-western extremity at Tanjong Buru, a distance of about 160 miles.

† The following are the heights of the principal eminences of the ranges in the neighbourhood of Singapore Town, above the level of low-water, at spring tides, as determined trigonometrically by J. T. Thomson, Esq.

	Feet.		Feet.
Lessuden	72·3	Lady Hill	108·0
Mount Erskine	88·3	Mount Victoria	100·8
Ansersabs Hill, or Mount Wallich	144·3	Mount Elizabeth	82·2
Mount Parsee or Palmer	119·3	Cairn Hill	113·2
Duxton	68·2	Emerald Hill	71·9
Craighall	65·0	Mount Emily	135·1
Guthrie's Hill	106·2	——— Caroline	108·1
Raeburn	45·2	——— Louisa	112·1
Everton	34·2	——— Sophia	108·3
Spottiswoode Park	73·5	Bukit Chermin	106·6
Line Hill	124·2	Hooden Field	70·2
Mount Farquhar	107·3	Saint James	54·3
Rosemary Hill	115·9	Monastery	72·5
Sisters Caroline & Catherine Hill	110·1	Mount D'Alguilar, south	80·6
Sri Menanti	81·5	——— ———, north	75·5
Mount Harriet	103·5	Bain's Hill	78·6
Nassim's Fine Hill	93·6	Briars	91·3
Broad Field	75·3	Swiss Cottage	80·5
Bonny Grass	85·5	Mount Helen	80·8
Annan Bank	80·5	Mount Arthur	80·0
Pavilion	108·3	Duncarn	75·5
Kiltiney House	94·4	Green Hill	87·8

[Perth

ranges and branches of hills are always narrow and separated by depressions, which form salt-water creeks at their mouths and flat alluvial valleys towards the interior. A subsidence of a few feet would submerge them and restore the original outline of the land,—a system of narrow, elongated, branching peninsulas, alternately swelling and contracting, the several ranges and branches always tending to a parallelism with the axis of the mainland. Singapore, for instance (excluding the western triangular portion, which is nearly separated from it by the inlets of the Pandan and the Kranji and forms a curious peninsula by itself), would then present five peninsulas running from N.W. by W., where they are connected, to the S.E. by E. for about six miles, when the four to the west would be cut off along a line nearly N. by E.; while the broadest and most easterly would continue its course in the direction of Tanah Merah Bĕsar, sending off branches to the north-east and forming the bulk of the eastern division of the island*.

The general direction of the Strait is transverse to that of the hill-ranges, but forms an acute angle with it. In reality, however, the Strait consists of a succession of depressions, each of which nearly coincides in direction with the axes of elevation of the land. The most western of these, about 22 miles long (N.W. to S.E.) and 18 miles broad, stretches from the south-west promontory of the Peninsula to the northern islands of the Bulan Archipelago, and is bounded on the east by the western coast of Singapore and the chain of islets which stretch from its extremity across the Strait to the N.W. point of Batam. The second basin lies between the S.E. coast of Singapore and the N. coast of Batam, both of which it deeply penetrates; the former

	Feet.		Feet.
Perth Hill	82·2	Mount Faber	300·7
Kaynan's Hill	98·7	Hill in front of Mount Faber	265·4
Whampoa's Hill	93·0	Red Hill	112·0
Monks Hill	78·4	Ulong's Hill	129·3
Draycott	84·2	Mount Zion	45·4
Sheriff's Hill, Sri Minanti	82·2	Peak Island	101·4
Sri Tanglin	86·5	St. John's	189·8
Mount Mary	102·7	Blakang Mati little Hill	202·9
Angus Back Hill	129·4	Pulo Brani Hill	161·5
Angus House	69·4	Bukit Timah	519·1
Pearl's Hill	170·9	Hill behind Green Hill	124·5
Institution Hill	121·9	Claymore Chinese Burying Ground	74·5
Government Hill	156·5	Hannifasah's House	71·2
Blakang Mati large Hill, or Bukit Serapong	301·7		

The elevations of some other hills have been determined also by Mr. Thomson:—

		Feet.
On the mainland—	Gugong Bău	749
	Marubukit	661
	Bukit Santi	645
On Pulo Bentan (Bintang Island)—	Gunong Bentan	1212
	Bukit Kijang	759

* The map shows the configuration of this part of the island well. All the portions represented there as alluvial are flat, and have been silted up in recent periods.

in the alluvial plain forming the districts of Rochor, Gelang, Kalang, Paya Lebar, and Siglap, with its long branches or inlets, extending between the hill-ranges to the middle of the island; and the latter in Batam and Bulan Bays*. Its greatest length, from the extremity of Batam Bay to that of the Singapore Plain, is about 15 miles†; its least, from Tanjong Siglap to T. Singkwang, about $8\frac{3}{4}$ miles; its breadth is nearly 10 miles. The third basin is the middle of a prolonged submarine valley which stretches northward into the Peninsula, where it forms the estuary of the River Johōr; on the south it penetrates the Johōr Archipelago, where it forms the Strait of Rhio separating Batam from Bintang. The fourth or most easterly basin, —about 18 miles long, 20 miles broad at its two extremities, and 14 miles in its middle,—lies between the south coast of the S.E. promontory of the Peninsula and the N. coast of Bintang.

2. *Geological Topography.*—In giving a general sketch of the geology we shall consider the District as divided into four zones nearly corresponding with the four basins of the Strait.

1*st zone.*—The first, or most westerly basin, has on its southern side a deep channel, free from islands, which opens into the second basin between Pulo Sambo Kichi and Pulo Sikijang. To the south of this channel a dense clump of islands commences, which stretches to the S.E., and includes Bulan with its conspicuous peak, from which the Dutch hydrographers have named the group the Bulan Archipelago. It remains to this day unsurveyed and unexplored either by the Dutch or English, and in some charts still figures as one island, although it must consist of several scores‡. It is separated by a narrow channel, called Sĭlat Batu Haji, from the west coast of Batam, which has a general direction coinciding with that of this basin. The northern part of the basin is shallow and contains numerous islands; and the same configuration is continued in the western section of Singapore, which is a congeries of narrow peninsulas, separated by mangrove creeks. The prolongation of the zone in the mainland, including the S.W. promontory, is flat and alluvial towards the W., and hilly towards the E.

The whole of this zone consists of stratified sedimentary rocks, sandstone appearing to predominate towards the west, and sandstone and conglomerate, intermixed with clay and shale, towards the middle. Towards the eastern side a broad band of shale, chiefly chocolate-coloured, occurs; and in the extreme east, where it abuts on the syenite of the 2nd zone, this shale is interstratified with sandstone and conglomerate.

The western portion is nearly all covered by the sea or alluvium, the only islands, except those belonging to Bulan Archipelago, being Pulo Rungkum (Alligator I.), Pulo Sĭnang (Barn I.), Situmbu Kichi,

* These bays are deeper than they appear on the map, and the numerous creeks and inlets which pierce the island between the hill-ranges are not laid down, no survey of the bays having been yet made.

† About twenty-one miles, if we include the valleys which have been inlets of the sea since the land attained its present level.

‡ I have examined the northern part, where I found a perfect labyrinth of islets.

and Bĕsar (Rabbit and Coney I.), all of which appear to consist of sandstone and shale.

In the next parallel to the east we find in Pulo Salu strata of claystone and chert, highly indurated, crystalline, fissile, bluish, greenish, and greyish; soft clay; quartz-veins; quartzo-ferruginous walls; a subcrystalline grit of a granitiform aspect and in some places with a greenish base;—between Salu and P. Sudong, reefs of iron-rock*;—in P. Kapal, fine, purplish clay; steatitic clay, indurated, white, with seams and walls of iron-rock; fine shale, indurated, purple;—in P. Piel Ayĕm, soap-stone of variable purity, indurated, coarsely foliated; hard steatite; iron-rock in seams and veins; the steatite at some places containing iron-pyrites, and locally iron-masked and cellular;—in P. Blakang Padang, coarse conglomerate, some of the pebbles of which are steatite, either pure or imbedding small quartz-grains; finer beds with much steatitic clay, generally of a light greenish colour, occasionally violet and red; broad beds of fine-grained sandy marl.

Returning to the north, we have in P. Marambong clay with quartz and iron-rock remarkably developed;—in the north-west division of Singapore at Tanjong Gul, clay, fine (as at Marambong), with quartzo-ferruginous walls; at P. Sambulăn and Tanjong Kling, clays traversed by ferruginous and jaspideous walls; much laterite-gravel;—at P. Dammar laterite soil, gravel, and fragments; the coast of Singapore facing it is lateritic; on the west bank of the mouth of the Jurong clays and sandy marl; iron-rock swelling up through it in mammillary and botryoidal bosses; ferruginous and jaspideous walls; large laterite blocks composed of small pebbles and fragments cemented together.

Following this band of strata to the S.E., we observe in the Sikra Islands clays chiefly, with ferruginous walls; in Sikra Laut numerous highly indurated, ramifying, mammillated, iron-walls; radiating and concentric laminæ of colour; thin beds of bluish-black and greenish clays. These rocks are continued across to the Old Strait. In P. Busong we find indurated sandstones and clays with irregular ferruginous walls; reticulations of quartz-veins; much disturbance of stratification;—in P. Bukum, clay with indurated walls; light-chocolate-coloured clay; laminæ of colour;—in P. Simakau and P. Siking, iron-rock; hard laterite;—in P. Jong, clay, white with a faint green tinge; a few conglomerate-beds; numerous iron-walls; concentric and radiating laminæ of colour highly developed;—in P. Sabaru conglomerate, sandstone, clay; numerous iron-dykes and laminæ of colour as in P. Jong.

The next parallel is composed chiefly of sandstone and conglomerate, but with intervening beds of clay, mostly chocolate and purplish. At particular places much iron-rock occurs, and ferruginous lamination is frequent, although not on the great scale of the Sabaru group. The principal exhibition of this band is in the high range of hills on

* This term is used for brevity in this general sketch. The most common form is the hydrous peroxide of iron; and the iron-rock throughout the district, I shall afterwards show, is the common rock of each particular situs disguised by a greater or less injection of iron.

the S.W. coast of Singapore, stretching from Suñge Pandan to Batu Blyĕr (where the highest sea-cliffs in the district occur), and continued in the island of Blakang Mati. Proceeding along the same line of elevation to the S.E., we find it again in P. Sikukur, the two Sikijangs and Subar. It reappears on the other side of the Strait, and on the same line, in the two Sambos (where we find sandstone, grit, and conglomerate, for the most part highly indurated and semicrystalline; clay, chocolate, light purplish, violet, greenish, and yellow; and iron-rock), P. Mĭrlam and the eastern portion of the N.W. point of Batam.

To the east of this line the chocolate and violet clays, which have hitherto either shown themselves as isolated beds or in narrow bands amongst the other strata, become continuous, occupying a breadth of about one mile and stretching right across Singapore in the direction of N.W. by W. This band includes P. Brani and the eastern portion of Blakang Mati, in both of which the colours vary much,—chocolate, purplish, different tints of violet, greyish, lilac, green, and in which sandstone-layers are intercalated. It is then lost for about six miles in the Strait, but is found again on the east side of Sambo Kichi and on the coast of Batam, at Pulo and Tanjong Dañgas.

2nd zone.—The second zone consists almost wholly of soft amorphous clay and sandstone with conglomerate; the latter, however, containing a good deal of clay either mixed with it or in separate beds. The clay in Singapore forms a compact tract of about sixty square miles, occupying the main body of the island*. On the south it is separated from the plain of Singapore by a narrow margin of sandstone, and then stretches across the island in a N. by E. direction to the Old Strait. On the west its boundary runs in a north-westerly line, nearly parallel to the chocolate clay band, for about eight miles, when it is deflected towards the N. in the direction of S. Kranji, in the vicinity of which it meets the Old Strait. In Bukit Timah, solid greenish granite and syenite, passing in some places into compact laminated felspar, are seen. On some of the other hills of the clay-tract, protruding blocks of syenite and granite are occasionally found. Where deep sections have been made through the clay, its structure and composition are found precisely to resemble that of adjacent blocks, while on the surface it has a remarkable uniformity of character†, and is easily distinguished from the sedimentary clays. The whole of this tract, therefore, is decomposed plutonic rock. The clay in some places, and particularly in the bottoms of valleys, where it is covered by vegetable mud and has undergone a natural bleaching, is a pure white kaolin, but it generally imbeds quartz-granules (in rare cases abundantly), and a few feet below the surface is mottled

* It is almost a square of eight miles, coinciding with the Peninsular axis; that is, two of its sides run N.W. by W. (the northern of the two giving its direction to the Old Strait from T. Pongal to S. Tambrau), and the other two sides running N.E. by N. (the northern of the two giving its direction to the Old Strait from S. Sinoko to the creek of S. Batang Hari, and the southern giving its direction to the ancient W. coast of Singapore Bay).

† The variable proportions of iron and quartz, however, affect this character.

with red in various degrees, in isolated or connected ramifying blotches or in parallel curvilinear streaks. Fresh sections exhibit various tints of red, lilac, purple, yellow, &c. Pure white streaks and zones also occur frequently, exhibiting a kind of irregular, broken reticulation. It is sometimes altogether of a dark red hue. When this is the case, masses of a half-decomposed iron-rock are generally found in it; and in most localities, where cuttings have been made, a similar rock occurs here and there in dykes and ramifying veins. On the sides of these veins laminæ of a red colour are sometimes seen, either parallel to the vein, radiating from points in it, or forming systems of concentric lines. The iron-rock is also found either strewed over the surface in amorphous cellular blocks and small pebbles, or below the surface, at depths varying from a few inches to a few feet, in layers of similar pebbles. With these pebbles others of jaspideous and porcellanous rock are frequently intermixed, and veins or strings of the latter are found in the deeper sections or in the half-decomposed crumbling granite which in a few localities is exposed at the surface. In some places patches of a vesicular jaspideous rock are frequent in the decomposed mass. These are sometimes considerably ferruginous. Fragments of semi-decomposed syenite and granite, ferruginous in different degrees, are common. When highly ferruginous, they are more or less vesicular, and the only unchanged constituent of the solid rock is the quartz. Even this is sometimes penetrated by the iron. The upper soil, or that which has been completely subjected to atmospherical action, is a clay with a greasy lustre, but often inclining to a dry friable appearance, in colour generally yellowish brown, but with lighter and darker hues in particular localities. In many hills it is highly ferruginous and of a deep red colour. This, with the smaller proportion of quartz, distinguishes it from the granitic clays of Pinang higher up on the west coast.

The easily accessible localities where ferruginous blocks are most exposed are the hills along the boundary between the plutonic and sedimentary tracts near Singapore Town, such as Mount Victoria (58)*, Sri Menanti (39), the hills connecting it with Mount Zion (38), the hill forming the extreme S.W. point of the granitic tract (33), the western hill of Dr. Oxley's nutmeg-plantation (36), Cairn Hill (50), the coast of the mainland from Tanjong Tanguloh to Pulo Nanas (at Tanjong Passier Mera and near S. Tukong), &c.

The sandstone and shale surround the plutonic tract on the W. and S., being found occupying the space to the N.W. of it up to the Old Strait, rising in the hills near Singapore Town to the S.E. of it, and, lastly, forming, with a great predominance of sandstone, grit, and conglomerate, all the eastern portion of the island, with the exception of the hills at Chañggĕi. At several places there is much ferruginous rock, as in the hills running south from the Mosque in the town to Tanjong Malang, and continued in the reefs off that point. On the opposite side of the flat of the Singapore River, and where the very same line, prolonged to the north, crosses the two bifurcations of the Tanglin Range, we find a considerable development

* The figures refer to those on the map.

of laterite-rock in Government Hill (35), Mount Sophia (48), and Mount Seligi (47), where the clay is intercalated amongst the sandstone, which latter is highly indurated.

On the Batam side of the Strait the sandstone is found from Suñge Ledi in Batam Bay to Bulan Bay, and at some places contains iron-rock. The east side of Bulan Bay and the whole N.E. promontory of Batam with Pulo Nongsa is granite, which differs from that of Singapore in colour and in being larger-grained.

3rd zone.—On the east coast of Batam, in contact with the granite, are found iron-rock and clay, and, in the granite, iron-dykes containing casts of shells. The third zone includes the island of Pulo Ubin, consisting of various forms of granite and syenite (often approaching to and sometimes passing into greenstone) and remarkable for its tabular and concentrically laminar structure and its extraordinary grooves, resulting from the action of decomposition on its rocks ;—the eastern promontory of Singapore has a similar composition ; Pulo Nanas or Kirimkin, and the mainland opposite are composed of greenstone-porphyry ; the hills on the mainland at Tanjong Tanguloh of decomposed plutonic rock, similar to the prevailing Singapore clay, and, like it, containing ferruginous and jaspideous fragments ; the small islets of P. Sijahat and P. Hantu III, consisting of foliated claystone and chert, varying from subcrystalline to highly crystalline, generally very hornblendic, and traversed in P. Sijahat by a dyke of greenstone-porphyry ; Pulo Tĭkong Bĕsar and Pulo Tĭkong Kichi are chiefly sandstone, highly indurated, and with iron-rock ; in the sea off the S.W. point of Tĭkong Bĕsar rocks of granite occur, called Batu Kapala Tua* ; Marbukĭt (Johōr Hill) is composed of clays and conglomerates, indurated, passing into crystalline chert, &c., and of quartz and iron-rock ;—the coast of Bintang, from Tanjong Kalumpong to Tanjong Subong, is probably granitic.

4th zone.—In the fourth zone we find on the east bank of the Johōr River, at Johōr Lama†, granite ; to the south of it, grit and conglomerate, from Tanjong Iladong to Tana Runto (in the conglomerate of which fragments, partially decomposed, of chloritic granite, some very little rounded, are found), and probably as far as Tanjong Boe ; in Gunong Bău and the lower hills behind it on the S. Karang, greenstone, varying from compact to granular, the latter approaching the fine-grained granites of Pulo Ubin ; along the south coast of the S.E. promontory of the Peninsula at Tanjong Tiram greenstone-porphyry ; at T. Telumpong, granite ; at Tanjong and Pulo Rumnia, shales, further to the E. passing into subcrystalline rocks ; at T. Penyusoh (Point Romania), Peak Rock, South Island, and Pedro Branco (not included in the map), syenite ; North Rock, shale ; along the east coast, facing the China Sea, at Tanjong Puñgai and Tanjong Kĭnawar, talcose sandstone and shale, sometimes semi-crystallized, with abundance of iron-rock in large rounded shining blocks, and quartz‡ ;—

* J. T. Thomson, Esq.

† This Bugis town is further north than the map extends.

‡ See my "Notices of the Geology of the East Coast of Johore." Journ. Ind. Arch. vol. ii. p. 625.

at Tanjong Lompatan, talcose shale, quartz, and iron-rock;—along the north coast of Bintang, from Tanjong Subong to the N.E. Point, syenite*; at the Point, talcose clay and shale with iron-rock†, and quartz (similar to T. Kĭnawar)‡.

3. *Character and Extent of each kind of Rock.*

1. *The Sedimentary Rocks.*—Viewing the district as a whole, we observe that amongst the sedimentary rocks the shales greatly predominate, the chocolate and purplish being the most common. The soft shales and clays are of far greater extent than the indurated, and are either quite soft, yielding to the hand, or have various degrees of consistency, up to so much hardness and toughness as to require the hammer to break them. They are in great measure a mixture of clay and fine siliceous granules, to which the term *marl* may be applied, but as descriptive of their consistency only, for none of them are calcareous. Those in which clay is in excess, so as to be completely plastic, are not frequent. The steatite, when it occurs, is generally in large proportion, but of limited extent. I have only observed completely indurated argillaceous and argillo-siliceous rocks of a cherty and jaspery nature, and considerable in extent, at Pulo Salu, P. Kapal, P. Piel Ayem, Tanjong Putri (western), Pulo Sijahat, Pulo Hantu III, and Tanjong Piñgrang §.

The sandstones and conglomerates are more often indurated than friable. In many cases the former have a subcrystalline texture, and the latter a compact siliceous basis, traversed by veins of quartz-crystals. The most numerous pebbles in the conglomerates are of a dull whitish quartz. Greyish quartz-pebbles are also common. Black, red, and yellowish pebbles occur sparingly, although in some localities more abundantly than in others. Felspathic pebbles, sometimes with a crystalline, but generally with an earthy fracture, are common, violet tints prevailing. The basis of the conglomerates, when not indurated, varies from clay, often chloritic or steatitic, to a friable earth or marl, sometimes also chloritic, containing an abundance of quartz-granules. The highly indurated and subcrystalline sandstones chiefly occur in Mount Palmer (24), Government Hill (34), Mount Sophia (48), and Mount Liligi in Singapore, and in the promontory terminating at Tanjong Sĭngwang in Batam.

2. *The Plutonic Rocks.*—Taking a similar broad view of the pluto-

* J. T. Thomson, Esq.

† Mr. Thomson says, that "Laterite in a fused state appears to have run into and over this stratum in several places so as to crack it."

The lava-like appearance of the hydrous peroxide of iron here and in numerous other localities is exceedingly deceptive. I was misled by it for a considerable period, and the views which I have communicated to the Asiatic Society respecting the geology of this region were more or less coloured by this notion. The ejected-fluid-aspect and blackish colours are entirely owing to the peroxidation and concreting process of the iron. Is not the iron-dyke in Mavrospilia, which puzzled M. Virlet d'Aoust (Expédition Scientifique de Morée, pp. 54, 55), capable of a similar explanation?

‡ Specimens from J. T. Thomson, Esq.

§ P. Pisang (N.W. of P. Kocob, beyond the limits of the map) and the east coast of Krimun Kichi are striking examples of this class of rocks.

nic portions of the district, the most general character that we observe is the predominance of felspar and the prevalence of hornblende,—quartz and mica being generally in small proportions, and the latter rare. Well-developed granite of the common type is found in very few localities on the northern side of the Straits, the plutonic tract of Singapore being very deficient in quartz and mica, most of the red clay hills which occur in it being probably decomposed greenstones and highly hornblendic syenites. Even Pulo Ubin, although it presents several decidedly granitic bosses, tends, on the whole, more to the felspatho-hornblendic character, which exclusively prevails to the eastward of it, in Pulo Kirimkin (Nanas), the mainland opposite, Pulo Sijahat, Gunong Bau, and the adjacent hills. The only considerable display of proper granite is that on the southern side of the Strait, in the north-east section of Batam and the north of Bintang*.

With respect to the granulation and composition of the plutonic rocks, every variety may be found, from the most compact hornblende and felspar, through granular greenstones, minutely grained greystone, syenite, and eurite, to large-grained granite. In Pulo Ubin we find the following gradations (the hornblende being in general either in nests of small granules mixed with felspar, disseminated in minute particles, or in long thin streaks): light reddish granite, with quartz, predominating; granite of a bluish grey tinge; syenite with felspar in excess; syenitic greenstone; greystone; grey felspar, transparent quartz with some black mica interspersed, and nuclei with the mica in excess; a quartzo-felspathic basis (pegmatite) with minute particles of mica and hornblende disseminated, in some places sparingly, in others abundantly, so as, on partial decomposition, to give the rock the appearance of finely-ground pepper; spherical nuclei of mica with a little felspar, surrounded by concentric laminæ; greenish grey saccharoid felspar, with crystals of quartz and nests of mica sparingly disseminated; whitish felspar, black mica, and hornblende; well-crystallized felspar, with dark green hornblende disseminated in granules, cloudy spots, and fibres; blackish greenstone or hornblende rock; felspar and hornblende confusedly aggregated; opake white felspar, tinged green, and blackish green hornblende in very large and distinct granules; very finely grained blackish greenstone approaching to basalt; basalt; opake bluish grey and white saccharoid felspathic and quartzo-felspathic bases, inclosing crystals and grains of hornblende and translucent crystals of felspar (closely resembling one variety of Vesuvian lava), in some places becoming compact, the hornblende granules sometimes so minute as to appear like fine black dust sprinkled on snow; in the group of rocks close to Ubin called S'kodo (from the supposed resemblance of one of the most conspicuous to a frog), there is found a regular large granitic crystallization, the hornblende being in well-defined crystals of various sizes and mostly fibrous.

3. *The Ferruginous Rocks.*—The iron-rock and quartz which are found so generally, and in particular localities so strongly developed, occur occasionally in broad irregular patches and bands, but usually

* I have not personally examined Bintang.

in walls, veins, and seams. Where they are most abundant the principal walls follow the direction of the beds, but are most frequently sinuous, and connected by branches with those adjacent. The beds themselves, in such cases, are generally bent in a similar direction. The sides of the beds, where not obliterated by these walls, are often indurated and acquire a shining mammillated surface. Sandstones are often divided into little cubical and rhomboidal compartments, being pervaded by a complete reticulation of a thin black ferruginous crust or wall, which, from the washing-out of the sandstone by the action of the waves, projects, like the sepiments of a honey-comb, from the surface.

In clays and shales (and sometimes in fine-grained sandstones) red-coloured laminæ are frequently seen in connection with the ferruginous walls and veins, and arranged either in lines radiating from points or in concentric curvilinear figures. The most remarkable examples of this laminar coloration occur in the islands of Jong, Sabaru, and Bukum. Another kind of lamination is often seen in ferruginous walls. In this the original laminæ of the rock are preserved, but converted into iron-ore. Sometimes they are swollen into a globular form. This seems to be the origin of most of the mammillated and botryoidal forms.

The associated iron and quartz are found developed on the largest scale at Marambong and Tanjong Kinawar; and more or less quartz is found in almost every highly-ferruginous wall.

The localities where the iron predominates over the quartz are very numerous. Amongst the more striking instances may be mentioned, in sandstones, T. Sirimbun, Mount Palmer, the coast of P. Tĭkong Bĕsar; and in shales and clays, P. Dammar, the coast of Singapore opposite, Tanjong Pĕnjuru, P. Siking, P. Sabaru, the lateritic portion of Government Hill, the north-east part of P. Tĭkong Kichi, and Tanjong Pungăi.

The iron-rock is generally a hydrous peroxide and different forms of brown hæmatite, compact and ochry. In most localities the proportion of iron varies much, and is often too small to entitle the rock to be called an ore, but patches and masses of ore occur abundantly, and some walls are almost wholly composed of it. Regularly crystallized ores are not frequent in considerable patches, but hæmatitic crystals occur in the body of pieces of compact ore; and the thin brownish-black and black ore penetrating ferruginated rocks in seams, forming the external walls or crust of mammillary and botryoidal, and the lining of tubular and cavernous, masses of laterite and iron-masked rocks, is sometimes composed of fine fibrous crystals. I have found large-crystallized hæmatite in ferruginous sandstone and shale near the boundary of the plutonic and sedimentary tracts to the westward of Bukit Timah, and in violet-coloured shale midway between the Chinese Tokong, on the Pandan, and Bukit Timah.

We have already mentioned the mode in which ferruginous rock occurs in the plutonic tract. The following is an analysis, made in England, of a specimen of the common ore of the dykes occurring in this tract.

Peroxide of iron (containing 56 parts of metallic iron)	80
Silica, lime, and alumina	5
Water	15

Sp. gr. 3·12.

Pyrites occur very rarely, as I have only observed them in a considerable nidus amongst the shale of Pearl's Hill in a mass of anthracite, in steatite at P. Piel Ayĕm, and in the granite of Pulo Ubin.

4. *Alluvium.*—All the valleys are filled up to a greater or less height with alluvium, the bulk of which has been deposited from salt water, the freshwater deposits being generally superficial, although in some places of considerable depth. As this formation, in all its varieties, is still going on before our eyes, I will here mention causes and effects together. It has been remarked, that, when the district attained its present level, the sea must have flowed up the numerous long inlets which everywhere penetrated the land. All the different rock-formations must then have been accessible to the sea. Let us revert to this period in Singapore, where we can easily trace our way back to it. At that time, in crossing from Batu Blyĕr to Tanjong Tanguloh eight arms of the sea had to be passed, each with its shores winding round the points and into the concave recesses of the ramifying ranges which separated them, and receiving from the multitude of hillocks the clay which every shower of rain removed from their surfaces. The whole land was so constructed as to allow the greatest amount of waste to take place under ordinary atmospherical erosion. Scarcely any flat ground existed. Everywhere acclivities rose from the sea only to attain a certain height and be again bent into declivities which sunk into the sea on the other sides. The upper part of the valleys filled rapidly with clay, mud-flats were formed there and along the margins of the inlets, on which the mangrove and other salt-water trees flourished, and by their decay gave a carbonaceous character to the mud. In the shade of these maritime forests the *kapiting* and *udang kiteh** built up their pyramids of mud and helped to elevate and consolidate the floor, while their excrements and remains, with those of numerous crabs and testaceous mollusks, contributed with the vegetable matter to give a new character to the clay. In the meantime the same process went on in the eastern part of the island, but the sediment there was more mixed with sand. The points at the mouths of the inlets along the whole northern coast of the second basin of the Straits then consisted of sedimentary strata, exposed to the action of waves and currents, and those in the east, in particular, formed of yielding sandstone, supplied a large quantity of alluvial matter, while the shales of the hills near the site of Singapore town freely gave their loose red soil to the sea. When the mangrove-marshes, with their mud-flats in front, had gradually approached the mouths of the narrow inlets, a new condition of things arose. The sand, no longer sinking into deep water beyond the influence of the powerful surface-agitation of the sea, was thrown upon the mud-flats,

* Burrowing crabs. The *udang kiteh* is shaped like a scorpion, and greatly resembles, if it be not identical with, the *Thalassina scorpionoides.*

and, during the north-east monsoons, the heavy waves from the China Sea piled it up in long belts in front of the mangroves.

The clayey sediment of the plutonic tract now accumulated more exclusively around the mangroves within these belts. As the sands extended, the waves no longer penetrated into the inlets. In the higher part of the valleys, and in the recesses of the lower parts, the water became brackish, the mangrove and its associates died out, and a new and more exuberant order of vegetation, in which palms and ferns abounded, took their places. A black peaty matter now formed rapidly, filling up all the hollows, spreading over the ancient mud-flats, and burying the remains of the mangrove-forests. The alluvium now advancing beyond the inlets into the gradually shoaling bay of Singapore, the three processes which we have described proceeded for the future simultaneously. One sand-bank after another was thrown up, and the streams from the valleys were deflected into lagoons between them, in which a succession of events analogous to that of the old inlets took place. In the upper part of each successive lagoon were brackish marshes, in which dense forests grew; and in the lower, and along the margins of the creeks as far as the water was salt, the mangroves kept their place, forming, with the sand, a barrier against the waves. Bank after bank arose, lagoon after lagoon was formed, until the whole of the ancient bay was converted into a marsh, covered with forest and containing a succession of dry banks of sand or *pĕrmatangs*, the last of which has formed the present lagoon of the Gelang, projecting its extremity, like a tongue, into the harbour of Singapore at Tanjong Ru (Sandy Point), and has given a common estuary to the streams from every valley that opens into the Singapore plain.

This history we narrate with as much confidence as if there had been human witnesses and chroniclers of its whole progress, because not only has it left its own records of all its stages, but its current events are repetitions of these, and afford the fullest explanation of each of them*.

The valleys have now perfectly level surfaces, covered with forest where plantations have not been formed; and the layers of which they are composed are the pure plutonic clay,—a dark bluish marine clay which is seen at the heads of the valleys on both sides of the island up to the foot of Bukit Timah,—a black, soft, vegetable peat, or rather mud, in some places of great depth where hollows have

* "The lower parts of the valleys are mostly swampy, consisting of sand, clay, and black peaty mud; of the latter there are considerable tracts constantly moist and exhibiting an extraordinary rankness of vegetation. Looking on one of these swamps covered with tall but slender trees, and dense underwood growing up rapidly, and from the looseness of the deep bed of black vegetable matter,—the accumulated remains of their short-lived predecessors—destined soon to fall in their turn, and considering the deposits of clay and sand which accompany and give rise to it, it is impossible to doubt that we see nature repeating the precise process by which the materials of most of the ancient carboniferous strata were brought together. Towards the sea these forest marshes give place to mangrove swamps."—*On the Local and Relative Geology of Singapore, including Notices of Sumatra, &c.* (by J. R. Logan, Esq.), Journ. Beng. Asiatic Society, vol. xvi. p. 525.

existed,—and sand. The plain consists of the same matter, sand and vegetable mud prevailing towards the surface in all the eastern part, where alone a considerable extent of either is found. The inner part of the plain, before it was cleared and partially drained, formed there a large marsh called Paya Lebar (broad marsh) with a deep bed of black vegetable mud in which a dense forest grew. The outer part, towards the range of sandstone hills forming the eastern margin of the plain, is a sandy flat, which, as it extends to the west, divides into long pĕrmatangs, with flats of clay and vegetable matter between them. The upper or eastern part of these flats often contains a considerable proportion of sand. The more inland banks continue across the inner part of the plain, making the first continuous coasts of the bay. Others, deflected in different directions, but generally trending more to the west and to the south of west, traverse the plain; the penultimate one extending along the Chañggie road up to Kampong Glam, and the latest forming the present coast terminating at Tanjong Ru. Although the force of the north-west monsoon has laid down the sandy debris of the eastern cliffs in these long pĕrmatangs extending to the western side of the plain, deflected all the eastern streams in the same direction, and is even bending to the west the mouths of the western streams themselves, and driving them all up into the extreme S.W. corner, where there will probably be ultimately but one outlet for all the waters that fall into the harbour, yet there are records of a time when the western side of the plain and the western inlets had their own pĕrmatangs. One of the most distinctly marked runs transversely to these inlets, or from S.W. to N.E., and it must have been formed while the greater part of the plain traversed by the pĕrmatangs from the east was covered by the sea. The only point where the Siglap sandstone-ranges are now wasting is at the Red Cliffs, but the hills stretching to the west of this for about a mile and a half, and gradually retiring from the present line of coast, are sharply scarped at all their points which project on the sandy plain, and the scarping of those forming the S.W. angle of the range was probably coæval with the formation of the pĕrmatang in question*.

Shells are found, often very abundantly, in the alluvial clay. Beds of Coral are also occasionally met with. The infrequency of deep excavations is probably the reason why, in localities inhabited from very ancient times†, human remains are so seldom brought to light. In the inner part of the Singapore plain a piece of coir-rope was found 6 feet below the surface, and a piece of wood bored through, and having the hole filled with the twisted fibres of a piece of rope, was found in the town of Singapore at a depth of 40 feet. Mr. Thomson bored through 10 feet of blue mud and 30 feet of ferruginous

* The pĕrmatangs of Singapore are inferior both in length and elevation to those of the large plain of Province Wellesley, facing Pinang, which have been formed by the waves of the Bay of Bengal. For further information on this subject consult the section headed *Rivers and Alluvial Formations* in my "Sketch of the Physical Geography and Geology of the Malay Peninsula," Journ. Ind. Arch. vol. ii. pp. 116 to 136.

† Journ. Ind. Arch. vol. i. p. 300, 302, and vol. ii. p. 517.

earth before this piece of wood was brought up. Other 40 feet of hard ferruginous earths and clays were pierced at this locality (near the Hindu Temple).

At the Gaol, 55 feet of blue mud, mixed with shells, were found resting on red earth mixed with the bark of trees.

At Teluk Ayer, near the beach, the layers bored through were,—

Soft blue mud with shells	40 feet.
Bright red clays alternating with brown and yellow clays	60 „

At the foot of Government Hill, near the Convict Lines, there were found,—

White clays	20 feet.
Red clays and laterite resting on a very hard white clay	30 „

In digging "Jocksing's Well," 9 feet of alluvial sand were found to rest on ferruginous gravel similar to that which occurs frequently on the hills near Singapore*.

We have not mentioned Coral as contributing to the alluvium of Singapore plain, because there is no evidence that it did so in a considerable degree. The eastern cliffs wasted too rapidly to allow of its growth in front of them, and mud and sand-banks, both unfavourable to the Polyps, were constantly increasing within the bay. The fresh water which it received from the interior would also be hostile to them. We shall at another place notice the localities where they flourish and the office they perform.

4. *Structure and Disposition in the Mass of the Rocks*†.

1. *Sedimentary rocks.*—With the exception of the sandstones in the eastern part of Singapore and those on the east bank of the River Johōr below Johōr Lama, which are nearly horizontal, the strata rise at various angles, generally high, and frequently vertical.

Their strike over the whole district approximates to the direction of the Malay Peninsula, or N.W. by N. It deviates, however, about $22\frac{1}{2}°$ on both sides, or N. by W. and N.W. by W., and this not merely at places distant from each other, but in limited localities.

Strata are very rarely found lying in other quarters of the compass, and such aberrations never extend far. The most striking exceptions are Kiltiney, adjoining Government Hill in Singapore, where the strata run N.N.E., as they also appear to do in the next hill to the west, Institution Hill.

* The above paragraph is from the paper cited in the preceding note. It is added, on the authority of Dutch writers, that in Banka, which is a part of the Peninsular band of elevation, and where tin pits are often dug to a considerable depth through the alluvium, there has been found a bed of turf, with wood which had been cut, below 20 feet of clay; a boat, differing from the kinds which have been in use from time immemorial, at a depth of 16 feet; and traces of a rice-field in another deep pit.

† I have obtained sections and measurements of the strata of many of the islands, but I reserve these for notices of these islands.

Amongst the most continuous lines that I have observed are that of Bukum, Jong, and Sabaru, nearly N.W. ½ W. throughout; the Batu Blyĕr sandstone-cliffs along a considerable portion of their length; some of the shale-beds extending from Tĭloh Blangah and Pulo Brani to Blakang Mati; the most southerly beds of Sikukur which are continued in the West Sikijang. But the greater number of the islands and points, where the stratification can be observed, present irregularities. Thus, to notice the most marked instances, proceeding from north to south, at Marambong we not only find the more ordinary oscillations, such as N.N.W., N.W. ½ N., &c., but bends and curves, so that at some places the beds run N.E. by E., N.N.E., &c. At Busong similar irregularities occur, as we see N.E., N.E. by N., N.N.E., N., N. ½ W., N.N.W. ½ W. At Tanjong Lompatan the strike is N.E., E. by S., &c. The more common variations are such as those of Batu Blyĕr Cliffs, N.N.W., N.W. by N., N.W.; Blakang Mati, N.N.W., N.W. ½ W., N.W. by W.; P. Brani, N.N.W., N.W. by N., N.W.; the hills east of the village of Tĭloh Blangah, N. by W., N.N.W., N.W. by N.; West Sikijang, N. by N.W., N.N.W., N.W. by N.; East Sikijang, N. by N.W., N.W. ½ W., W. by N.; Tanjong Piñger, N. by W., N.N.W., N.W. by N.; N.W., N.W. by W. at Tanjong Malang; N.W. by W. and N. by W. in Mount Wallich (25); N.W. by W. and N.W. by N. in Pearl's Hill (28). The most prevalent strikes recur in almost every locality where the strata are well exposed. N. by W. beds are seen in Sambo Kichi, Tanjong Piñger, Tĭloh Blangah, and both Sikijangs, Mount Palmer (24), Mount Wallich (25), and Tanjong Pagar; N.N.W. in T. Piñger, T. Dangas, Marambong, Sikra, Batu Blyer, Blakang Mati, Pulo Brani, Tĭlo Blangah, Sikukor, West Sikijang, Tanjong Pagar, Tanjong Malang, Government Hill (35); N.W. by N. in T. Piñger, Batu Blyer, T. Blangah, P. Brani, and West Sikijang; N.W. in Piel Ayem, Tanjong Gul, Batu Blyer, Hodin's Hills, Pulo Hantu II. (12), Panti Chirmin (13), Pulo Brani, and Blakang Mati, Tanjong Malang, and the east point of Bintang; N.W. ½ W. in Bukum, Jong, B. Blyer, B. Mati, West Sikijang, and Tanjong Puñgai; N.W. by W. in Sabaru, Batu Blyer, Hodin's Hills, T. Blangah, P. Brani, Blakang Mati, Timukul, Mount Wallich (25), Dickinson's Hill (29), and Pearl's Hill (28); in the shale-beds between Tĭlo Blanga and the Sepoy Lines (30), N.W. in the same beds to the west of Bukit Timah.

The variations in dip, like those of strike, have a general character of uniformity, with considerable occasional deviations. Vertical or approximately vertical strata occur in P. Blakang Padang, Sambo, T. Piñger; T. Busong, Jong, Bukum, the Batu Blyer Range, Hodin's Hills, the N.W. point of P. Blakang Mati, the Tĭloh Blangah Hills, Mount Palmer. Oscillations may be observed in Marambong; in Busong; in the Batu Blyer Range of about 70°, or from 25° W.* to vertical and a few degrees from vertical to the E.; in Tanjong Piñger about 75°, or from 20° W. to vertical and a little to the E.; in P. Blakang Mati of about 45°, or from 50° W. to a little E. of vertical; in West Sikijang of about 90°, or from 45° W. to 45° E.; in

* W. and E. are here used for westerly and easterly.

East Sikijang about 35°, or from 45° to 80° E.; in the range terminating at Tanjong Batu (Singapore) about 85°, or from 50° W. to 45° E.

A high inclination being very common, a decided tendency to a dip in one direction is not to be anticipated. In several localities the rocks dip away from vertical on both sides, indicating the existence of synclinal axes, which in a few instances are seen, as in the N.E. point of Blakang Mati, Mount Palmer, &c. The only distinct anticlinal axis that I have observed is in a hill forming the south point of West Sikijang, where the strata are arched.

Notwithstanding this tendency to verticality, the westerly dip on the whole predominates in the western part of the district, for, although beds having an easterly dip are found in P. Mirambong, P. Blakang Padang, P. Busong, P. Jong, P. Sabaru, the Batu Blyer Range, P. Hantu, Blakang Mati, Sikukur, West and East Sikijang, T. Piñger, Mount Wallich, Mount Palmer, Kiltiney Hill (34), &c., and in some cases the dip is exclusively to the east, yet in most of these localities the beds that dip to the east are associated with a greater extent of beds that have a westerly dip. In the eastern part of the district, however, the dip is generally to the eastward, as at the Tĭkongs, Tanjong Puñgai, and the N.E. point of Bintang; but it is not uniformly so, for at Tanjong Lompatan it is about 45° W. In the next considerable exposure of rocks on the east coast, those of Sidili Point, to the north of the district, the dip is again easterly.

The strata, although where iron-rock and quartz occur often much disturbed, and sometimes in patches, broken up and mixed, forming a hard ferruginous breccia, are nowhere completely shattered, and the fragments confusedly mingled, except in considerable portions of Government Hill (34), Mount Sophia (48), and Mount Siligi (47), where no beds are distinguishable, the hard sandstone being scattered through the clay, at some places in angular blocks from a few inches to several feet in diameter, and in others as a fine breccia.

2. *The Plutonic rocks.*—The prevalence of felspar and hornblende renders these rocks very decomposable when kept exposed to the influence of water under ground. Hence while blocks rising above the soil suffer little waste, the mass below is almost everywhere converted into clay to a considerable but unknown depth. The only locality in the district where rocks have escaped decomposition in sufficient number and size to display their structure is Pulo Ubin. This has probably been owing to the steepness and narrowness of the range of which it consists, and the action of the sea along both its sides, which have combined to degrade and wash away the decomposed portions, thus leaving the more resistent masses to emerge from the soil and stand out above the influence of decomposition*.

All the numerous exposed blocks of Pulo Ubin have a large laminar or zoned structure. The laminæ are in different forms, flat, spherical, and concentric, and variously curved; but the systems of circles

* When an exposed rock is attacked, the decomposing portion is washed or falls off, and the decomposition is arrested for the time. Under-ground decomposition tends to spread unchecked on all sides.

and curves seen in horizontal sections are generally portions of a connected system, of which the external laminæ are rectilinear, or nearly so. The principal rectilinear planes of division approximate in their general direction to N.E., S.W., or at right angles to the axis of elevation of the region.

Transverse and approximately horizontal planes of division exist, so that the rock tends everywhere to break into spherical, cuboidal, and tabular masses. Its composition in many places varies with the structure; and the unequal wasting thereby occasioned has given rise to very singular external forms in the exposed masses. The most common are cuboidal rocks, from a few yards to twenty and upwards in diameter; having their sides traversed by concave vertical grooves, varying in depth from a few inches to about six feet; the sides of the larger concavities being often grooved in their turn. These grooves generally extend from the base to the summit of the rock, a height in some cases of about 40 feet, although generally much less. On the upper surfaces, and on the sides where they are inclined, a succession of hemispherical and pear-shaped cavities are frequently seen; and, where they are wanting, less regular furrows, corresponding with divisional planes, generally supply their place*.

The true explanation of all these phænomena I believe to be that which I offered towards the conclusion of the paper mentioned in the preceding note. It is as follows:—"The blocks, protruding from the hills or ranged along the shores of Pulo Ubin, are more solid and less decomposable masses and nuclei, of which the forms, with the directions of their sides and axes, have, in almost every instance, been determined by structural planes, and which remain after the surrounding rocks have been disintegrated and washed away. With respect to the latter, it is obvious that while the island has been extending by the growth of alluvium in its bays, its more open coast has been slowly retreating, so that what was once a part of the solid land is now a band on its border washed by the sea, but still exhibiting numerous rocky remnants. The larger masses still evidently occupy their original positions. Frequently their seaward face is curved. Sometimes another mass stands behind, merely separated from that in front by a chasm whose sides are parallel. With respect to the decomposition of the rocks on the hills, the soil is entirely derived from this source, with the exception of a very slight superficial mixture of vegetable matter, which in many places is absent. In general, however, the blocks that remain are decomposing with exceeding slowness. One exception I noticed in the N.W.–S.E. side of a block about 20 feet in height. The laminæ being inclined inwards, in disrupting by their own weight fall some feet in front of the base, where a long mound of earth has consequently accumulated. I have now only to revert to the grooves. The circumstances attending them which any hypothesis of their origin must explain are these: their general prevalence; the existence, however, of exposed rocks devoid

* I have described the rocks of Pulo Ubin in detail in a paper communicated to the Batavian "Genootschap van Kunsten en Wetenschappen," in 1847, and published in the 22nd vol. of their Transactions.

of them; their being commonly confined to the sides facing the exterior of the island, although sometimes found on other and even on all sides of a rock; their great depth and regularity; their general coincidence with divisional lines; their conformity to the course of rain; and their antiquity. It is this last circumstance which, presenting at the outset a great difficulty, leads, on further consideration, to what I consider the true explanation. That meteoric influences have been the great agents of erosion I have already suggested. But the antique and permanent character which is impressed on the great majority of the rocks, their vegetable coatings, the hardness and sharpness of the external edges of the grooves, prove that the rocks must have existed under very different conditions from the present, to enable atmospheric forces to produce results of such magnitude. The considerations which have hitherto occupied us in the concluding portion of this paper appear to me to indicate what these conditions were. The composition and structure of the external rocks, unveiled by the action of the sea on the beach, show zones of soft rock*, rows of globular decomposing masses, and of harder ferruginous spheroids, &c., susceptible of being detached, and a general tendency to perpendicular division. If, therefore, we conceive the external layer of the island, when it first became exposed to decomposition, to have resembled in character the zone that has been laid open for our inspection along the beach, it is easy to comprehend how the wasting away of the more decomposable parts might at last leave exposed masses, including bands of the less stubborn material already partially softened or disintegrated under ground, and that the action of the atmosphere and rain-torrents would gradually excavate the more yielding portions, until the solid remnants exhibited their present shapes."

II. Meteorological and Hydrological Influences.

We have necessarily anticipated much belonging to this head. The mean annual temperature of the district is about 81° 25′ (that of the hottest and coldest months differing about 2° 76′); the range from 6° to 7°; the fall of rain about 92 inches distributed over every month in the year, with a considerable excess from October to January.

All the climatic forces which operate on the land are affected by the two monsoons which prevail in the Indian Ocean and China Sea. During the S.W. monsoon from April to October, the Straits of Singapore being to the leeward of the mountain-range of Sumatra, equable weather is experienced in the district. Showers are frequent but seldom long-continued, and the monthly mean of the thermometer ranges from 81·21 to 82·31.

During the N.E. monsoon from November to March, while the

* Some rocks may be seen along the beach with chasms 2 or 3 feet wide, the sides being quite hard and the bottom a soft decomposed substance. In such a case a zone of rock differing in composition from that adjoining has evidently been gradually decomposed and washed out.

Straits of Malacca are sheltered by the mountains of the Malay Peninsula, the eastern coast of our district is exposed to the full force of the monsoon, and the hills that stretch along it are not sufficiently high to destroy, although they considerably modify its influence in the Straits. During the greater part of this monsoon rains fall abundantly, the streams are frequently swollen, and sometimes overflow their valleys, the sun is obscured more frequently and for longer periods, the temperature is lowered, strong winds often prevail, and the sea is more agitated. It is, therefore, in this monsoon that the erosions an. abrasions of the land referable, mediately or immediately, to the climate are greatest.

The heat and humidity of the climate affect the solid inorganic mass of the land chiefly by their favouring the decomposition of the rocks, the growth of vegetation, and the degradation of the soil. These operations are much less marked than those of the sea, but they are incessantly progressing over the whole land, and their effects, when accumulated by time, must be very great. The soil is always kept moist, which causes the decomposition of the plutonic rocks to descend to a great depth; and the rain, the most constantly acting and universal mechanical agent of geology, and here gaining a maximum of effect from the configuration of the ground, falls on an average about half the number of days in the year. When it is considered that every considerable shower in Singapore is the parent of innumerable little rills,—each turbid with fine clay and propelling quartz-granules, &c.,—which pour down the sides of hundreds of hills into the valleys, the great beds of alluvial clay appear less disproportioned to the size of the streams. These are very numerous, but, owing to the low level of the country, insignificant; the broad and deep salt-water creeks, which occur at short intervals along all the coasts* and seem to be the estuaries of considerable rivers, seldom extending beyond a few winding reaches, at the top of which they dwindle to petty rivulets of fresh water. None of the Singapore streams have courses longer than six miles, and it is only after heavy showers that they pour down a considerable body of water. The continental part of the district includes one large river, the Johōr, the course of which, in a direct line from its source in Gunong Blumut to Tanjong Tĭkong, is about fifty miles; but it may be said to fall into the sea to the north of the district, because the long and broad estuary as far up as Tanjong Gĭdong is an arm of the sea. It has caused the formation of a large alluvial tract extending along the west side of the estuary. The other rivers of the mainland falling, with one exception, into the Old Straits, such as the Pulai, Sakodai, Tambrău, Lĭbam, and Santi, have all elevated the beds of their valleys to some distance from the Strait to a level between low and high water-mark, and covered them with marine forests. Thus in every valley of the district some of the alluvial processes before-described are constantly proceeding.

The Straits, as we have seen, are sheltered from the direct influence

* The eastern coast of the mainland and the S.E. coast of Singapore must be excepted.

of both monsoons, and it is only when the China Sea is agitated by strong or continued winds during the N.E. monsoon that heavy waves roll into the Strait, and attack all the exposed shores of the three most easterly basins*,—the Peninsular coast from Point Romania to Marbukit, the Batam coast as far west as T. Siñgkwang, and the south-east coast of Singapore.

The east coast of the Peninsula and the north coast of Bintang, lying on the China Sea, are at all times exposed to the action of its waves; and the abrasion at all the points, notwithstanding the solidity of the rocks, has been great. It is particularly observable at the promontory terminating in Tanjong Puñgai and Tanjong Kĭnawar, the first of which points is covered with massive globular blocks of iron-ore gleaming like gigantic balls of polished metal, the indestructible fragments of a hill, one-half of which has been destroyed, and of which the cliff behind, notwithstanding its masses of iron-rock, is year after year yielding more spoil to the waves. The hill at the second or northerly point, being less ferruginous, has been ground down to the level of the sea, and nothing is now left but the long quartz-penetrated ledges of its foundation. The extremity of the Siglap and Tana Mera hills on the east coast of Singapore, being composed of soft sandstone and conglomerate, are annually suffering abrasion; large fragments falling down during every N.E. monsoon. The waste here must have been enormous, for the abraded sand has completely blocked up the whole S.E. coast of ancient Singapore, so that for about ten miles the only spots where the sea touches it are the two hills, the abrasion of which forms Tana Mera Bĕsar and Tana Mera Kichi (the Red Cliffs). This long sand-bank, which has completely dammed in all the water of the plain of Singapore, is the best measure which the Straits afford of the power of the waves raised by the N.E. monsoon, and it is worthy of notice as an instance in which the compensatory effects of abrasion far exceed the destructive, as respects the superficial proportion between land and sea.

"The sedimentary ranges to the west of Singapore plain, which are variously indurated, charged with iron, and highly inclined, have opposed greater resistance to the sea; but the quantity of soft clays and shales which they contain has facilitated its action, and long ribs and ledges of iron-masked rock, stretching across the banks, mark at once how difficultly destructible they are in themselves, and how unavailing they have proved to save the hills which they bound together. At one place the sea has cut through some highly indurated strata and divided an island (Blakang Mati) in two, and a strong current rushing through this narrow gateway into New Harbour, its old circuitous route around the northern end of the island has gradually been filled up with mud, and the detached northern half thus united to Singapore. The islands in the Strait are all greatly abraded†," and many of them have long ledges running out

* The tidal current sometimes runs for eighteen hours of the twenty-four into the Strait during springs, and for two or three days without interruption during neaps.

† This paragraph so far is copied from my Essay on the Geology of the Peninsula cited before.

from their extremities or exposed at their sides. When the sea has worn down a portion of one of these islands below its level, the coralline polyps that incrust its outer margin, where it sinks into deep water, begin to advance upon it towards the land and preserve it from further abrasion. Were it not for the causes to be mentioned, this curious organic shield would effectually defend the rocky foundations of the islands from the attacks of the sea; and in process of time, when the Strait was denuded of all the hills that now rise above its surface, each of them would be represented by a coral-reef of an irregular annular shape*. But in many localities, after the corals have flourished over a considerable horizontal space for some time, yielding strata of sandstone come under the influence of the waves, which grind them down and spread the sand over the coral-field. The speedy consequence is that the polyps perish, and in their place a bed of sand and dead coral is left, which sometimes cements into a hard calcareous layer, but generally becomes a prey to the sea. Living coral-fields are found in all parts of the Strait, but most abundantly in the north-eastern portion of the most westerly basin in the shoals around and between its numerous islets. Beaches from which corals have perished occur frequently; amongst the largest being those in front of Blakang Mati village, the east coast of Sambo Bĕsar, and Bukum. On coasts of soft wasting sandstone they are seldom found; and in the proper mangrove localities, that is, in sheltered places where mud accumulates, they are either wanting or are scattered in small and weakly patches on spots where sand occurs. Their proper habitat is a beach or shelf of indurated rock abraded to a level below that of the ebb-tide, sinking at its outer margin into deep water, and with a free exposure to the sea so as to be constantly scoured by the waves. Such shelves seldom preserve all these conditions up to the land, so that there is generally an inner space from which the waves retire at ebb-tide. It is still moist, full of small pools, and dotted with pieces of living coral, but the continuous coral-beds growing luxuriantly in

* If the Strait were to remain perfectly undisturbed by subterranean forces, neither undergoing subsidence nor elevation, it is obvious, from what we now see to be going on, that these two antagonist powers, water and the coral-polyps, would, in the course of time, leave the Strait without any vestige of land, save some reefs and rings covered and shielded by the coral. These two simple and ever-operating agencies, mechanical and organic, appear sufficient to explain the fact, that patches of land are found over vast spaces of ocean at the same level. Let the present condition of things last long enough, and an aggregation of mountain-groups, like that of the Malay Peninsula, will be abraded, broken into islands and coral-reefs, until island after island is worn down beneath the level of the sea, those only remaining at that level in which the conditions for the continued existence and growth of coral are maintained throughout the process of degradation. In endeavouring to follow out such a process from the facts presented by a coralline sea, like that of the Straits of Singapore, the shores where coral is absent are as instructive as those where it is present; for whatever successive changes the configuration and disposition of the land may undergo in the progress of denudation, the same causes will continue to favour and oppose coralline growth so long as wasting shores and streams of fresh water exist. The process would accelerate as it advanced, and a condition of things approximating to that of the archipelagoes in the open ocean be reached, in which both the mechanical and organic powers are greater than in the Strait of Singapore.

all their variety of rich colours and beautiful forms, giving a gorgeous pavement to the sea, are not found until this space is passed.

In some places solid beds of calcareous conglomerate are forming on the beaches; and ferruginous conglomerates, breccias, and sandstones are found wherever highly ferruginous rocks exist behind sandy shores.

III. Relation of the Rocks to Animal and Vegetable Life; and their Economical Uses.

Although the soils of the district have not the fertility of the volcanic and calcareous soils which occur in many parts of the Indian Archipelago, they are covered with an indigenous vegetation of great vigour and luxuriance, supporting numbers of animals of different species. The hills of plutonic rock support dense and continuous forests, composed of more than 200 species of trees *, many of which are of great size. So long as the iron is not in such excess as to recompose the clay into stone, or render it hard, those soils which contain most iron are the most fertile. The purely or highly felspathic are the worst. But even felspathic soils, when they have a sufficient proportion of quartz, are, in this climate, capable of producing an abundant vegetation.

Although it is obvious to every observer that there is no kind of soil in the District for which nature has not provided plants that flourish luxuriantly in it, yet it must not be hastily concluded, as some have done, that this exuberant vegetation indicates a general fertility in the soil. It is found, on the contrary, when the native plants are destroyed, and the land employed for agriculture, that there are very few soils in which cultivated plants not indigenous to the region, but whose climatic range embraces it, will flourish spontaneously. While the cocoa-nut, betel-nut, sago, gomuti, and the numerous Malayan fruits succeed well with little care, the nutmeg and clove are stunted and almost unproductive, unless constantly cultivated and highly manured; yet the climate is perfectly adapted to them. Place them in the rare spots where there is naturally a fertile soil, or create one artificially, and their produce is equal to that of trees in the Molucca plantations. With respect to the indigenous plants, gambier, pepper, and all the fruit-trees flourish on the plutonic hills, provided they are not too deficient in iron and quartz. The hills of violet-coloured shale, where they are not too sandy, are equal to the best plutonic soils,—those, namely, in which there is a sufficient proportion of hard granules to render them friable, and sufficient iron to render them highly absorptive of water without becoming plastic. The sandstone and very arenaceous shale soils are the worst. Of the alluvial soils, the sand, particularly when it contains a mixture of vegetable matter or triturated shells, is the proper soil of the cocoa-nut, and the vegetable mud is best suited to the sago. When the country has been better and longer drained and cultivated, the latter soil will become a rich mould; at present it is every-

* My list contains at present 217 trees, but it is not complete.

where too wet and sour to make a fertile soil. Rice is grown on some patches of it. The bluish sea-mud contains good ingredients, but clay is in excess, and the animal matter appears to assist in rendering it hard and untractable when it is not saturated with water. Even for such a soil nature has provided plants useful to man, for the betel-nut and some of the indigenous fruit-trees grow well in it with little cultivation. Although there are cultivated plants adapted for every kind of soil in the District, and it has indigenous tribes who can live exclusively on its yams, sago, fish, and wild animals, it is incapable of feeding a population of the more civilized races; and the latter must always be dependent on other countries for the great necessary of life, viz. rice.

The rocks which are used for economical purposes are not numerous. The only edible one is the fine clay called *ampo*, which is made into thin cakes, smoked, and kept for use.

The plutonic rocks, and the indurated sandstones and conglomerates, are used for the foundations of houses. Lateritic stones are sometimes used by the Malays as pedestals for the posts on which their small houses rest. Granite is used for steps, milestones, tombstones, &c. Of the blue alluvial clays the bricks and tiles are made, of which the town of Singapore is built. The fine kaolin which abounds has been found the best adapted of any in India for the manufacture of porcelain, but no manufactory has ever been established*.

IV. Traces of the Geological History of the District.

Having thus given a general description of the actual constituents and arrangement of the rocks of the district, we have next to inquire whether they preserve any evidences of its past geological history, and I think the following conclusions may be safely adopted.

1. Ceasing for a moment to view the district as isolated, it is established that it is a portion of the zone of elevation extending from the Himalayas (or their vicinity) to Banka, or rather to the granite patch in Java; approximately parallel to the plutonic zones of Burmah, Siam, Cambodia, and Anam, which seem to terminate in Borneo, and surrounded by the great volcanic band of the Indian Archipelago, the most active western portion of which, Sumatra, is semi-plutonic, and is parallel and adjacent to the Malay Peninsula; separated from it only by the broad and shallow submarine valley of the Straits of Malacca†.

2. The sedimentary strata of the district were deposited prior to the elevation of the Malay Peninsula, and therefore prior, probably, to the elevation of the whole south-eastern region of Asia.

3. They were formed from the abrasion of a tract composed chiefly of clays, and probably partially elevated above the level of the sea, or at least so near its surface as to be subject to strong currents. These appear to have prevailed along some of its wasting shores in

* See Dr. O'Shaughnessy's Report of Experiments made by him for Government.

† See "The Physical Geography and Geology of the Malay Peninsula," Journ. Ind. Arch. vol. ii. p. 89–93.

the vicinity of Singapore, for the water-worn pebbles of the conglomeratic beds entirely resemble, in their variable size and occasional deficiency of abrasion, the gravel at present accumulating in the vicinity of the sea-cliffs. The mode in which they are disposed shows that they were from time to time driven and irregularly heaped by violent currents or waves.

All the sedimentary beds of the district form one series accumulated from the debris of the same rocks, and the region underwent no violent upheaval during the period of their deposition. This is an inference from the generally uniform mineral character of the beds,—particular kinds of clay or shale prevailing everywhere, and the conglomerate layers, wherever they reappear, exhibiting the same peculiar clayey matrix and the same prevailing pebbles. No instance of unconformable stratification has been observed.

The ancient land consisted chiefly of two rocks; 1st, a fine, tough, easily frangible clay, of which the prevailing colour was a dull violet; 2nd, a granite composed of quartz, chlorite, white felspar, and a fine silvery talc, the last sometimes wanting, and all the ingredients apparently varying greatly in their relative proportions at different places. The first rock, reduced to sediment, produced the shales and clays of the district, and, in rolled fragments, furnished a portion of the pebbles of the conglomerates. The second rock, disintegrated and partially decomposed, produced by its debris the great bulk of the conglomerates, of which the matrix is generally quartz-granules mixed with more or less of chloritic or steatitic earth with greenish and yellowish hues. It also furnished a few shale-beds in which chlorite is contained. The quartz-pebbles, generally whitish, but sometimes of black and other colours, were probably derived from this granite also, the quartz in some specimens tending to segregate. It probably existed likewise in contemporaneous veins and nodular masses. The granite, where free from chlorite or the larger developments of quartz, furnished the granules of the sandstone-layers; or these may have resulted from a more thorough decomposition of the granite, and the washing of the chlorite and felspar to a distance from the place where the sand accumulated, just as we see, at present, partially angular and rolled fragments accumulating in the vicinity of wasting points, the more finely disintegrated sand carried to some distance and accumulated by itself, and the clay suspended and deposited over a far wider surface, extending to a considerable distance.

4. The rocks of this ancient tract differed from the existing plutonic rocks of the district, and the latter were not in existence at the time of the deposit of the sedimentary beds, for no fragments resembling them have been found in these beds, and many of the rocks which most abound in them nowhere exist in the present plutonic rocks. The most conclusive fact is the entire absence of iron-masked pebbles or fragments in the sedimentary strata. The abundance of ferruginous walls in the latter and in the decomposed plutonic rocks, and the constantly recurring layers of ferruginous pebbles and blocks in the modern debris on the surface of the land and along the shores of the wasting points of both formations, prove that beds derived

from their decay will be principally characterized by their profusion of such pebbles and blocks.

5. The upheaval of the sedimentary rocks was in general attended with great violence, as is shown by the irregularity in the strike and dip of the beds in numerous circumscribed localities, and the breaking up and mingling of those in Government Hill, &c. Where there are most evidences of violence, there is the greatest development of iron or quartz. The line of disturbance, for instance, which goes through Government Hill, and is continued in the hill south of it, ending in Tanjong Malang or Batu, is marked in the latter by iron-masked blocks and gravel on the surface, sandstone indurated and pervaded by an iron-honeycomb, iron-mammillated crusts on the sides of the beds, &c., and in Government Hill by the clayey beds adjacent to the disrupted sandstone being converted into the typical laterite, and by the sandstone at some places near the junction being broken into a mass of small fragments recemented by iron and clay*.

6. The formation and intumescence of the plutonic rocks of the district caused this upheaval, and gave the prevailing direction to the stratification and to the ranges of hills, this direction agreeing with that of the plutonic zone of the Peninsula.

7. The partial metamorphosis, induration, and *ferrugination* of the sedimentary strata were effects of this plutonic action.

8. The vast abundance of iron evolved during the plutonic intumescence, and rising into the strata, is the distinguishing peculiarity of the Malayan zone of elevation†, and its wide-spread effects so strongly strike the eye that the other changes are less observed; but the latter evince even more decidedly the potency and the unity of the elevatory agent, and are particularly worthy of attention as assimilating that agency to the more common kinds of plutonic metamorphosis. The soft strata in some places have been converted into Lydian stone, porcellanite, clay-slate, hornblende slate, steatite, and chert. If we extend our observations a little beyond the district, we find similar changes on a much greater scale. Thus the eastern coast of Pulo Krimun Kichi (Little Carimon), which rises only eighteen miles to the west of the last of our sandstone islets in that direction, is composed of a conglomerate converted into the hardest chert. In many of the islands in the China Sea off Pahang the metamorphosed rocks are so indistinguishable from greenstone, that we can only recognise them as sedimentary by the presence of pebbles which some of them contain. In Pulo Tioman the junction of granite with a green, grey, and black hornblendic rock is well displayed, the granite sending veins into the hornblende, and masses of the latter being sometimes imbedded in the former, clearly proving that the hornblende, whether volcanic or (as I believe) metamorphic, is the more ancient rock.

* I trust to be able ere long to give a full account of the mechanical effects of the upheaval in different parts of the district.

† But common to it with the adjacent belts rising from the same platform—that of S.E. Asia—and the approximately parallel and probably contemporaneous Peninsula of Southern India. This peculiarity is found in S. India, Bengal, the Malayan belt as far north as it has been examined, Borneo, and the N.W. part of Australia.

9. One of the most striking characteristics of the district is the protean nature of the plutonic transformations, remarkable alike in the diversity of the plutonic rocks themselves, and in the numerous degrees and kinds of change which the plutonic agency has produced on the strata. There are considerable tracts in which the granite undergoes little variation, but which differ decidedly from each other. There are tracts where the plutonic rock graduates or passes abruptly from large-grained granite to the most finely grained, or, losing its quartz and mica, passes into greenstone or into compact felspathic or hornblendic rocks. Amongst the sedimentary rocks we find that some, near the line of junction with the plutonic, have merely become ferruginous, while others, apparently distant from it, have become highly indurated. The same rock, completely iron-masked at one place, exhibits no change whatever a few feet off. We have seen that the mechanical action to which the strata have been subjected participates in this want of uniformity.

10. Is the explanation of this character of the district,—the absence of all other sedimentary formations but the existing limited one, the entire disappearance of the ancient rocks which composed the district when the present strata were being formed, and the mode in which the plutonic exhalations have freely risen through the latter,—to be found in the circumstance of the plutonic action having extended to the surface of the ancient land (whether beneath the sea or not is another question) and assimilated it all, excepting a thin crust of the newest and highest beds, or rather bands and patches of that crust, which now lie scattered over the great plutonic mass of the Peninsula? It is clear that granite does not require a greater pressure for its formation than the so-called volcanic rocks into which it passes. In Pulo Ubin and other localities, we see, in the same rock, at one place a perfect granite, composed of large crystals of quartz, felspar, mica, and hornblende, and at another a compact or finely granular greenstone or basalt, so that the granitic form does not necessarily depend on the depth at which crystallization or plutonic metamorphism takes place*.

11. At the time of the upheaval of the strata they were new, and had neither been consolidated by great pressure nor indurated by any prior plutonic action. Where they have escaped the influence of the ferruginous and siliceous exhalations, and the heat given out during their elevation, the more aluminous beds are still soft clays, and the arenaceous slightly coherent sand, sometimes not distinguishable from the beds of clay and sand forming along the shores at present.

If the now visible plutonic rocks had been formed at a great depth and under a vast equal pressure, they would have been more uniform in their composition and structure, and in their action on the immediately superincumbent strata. They would have more slowly cooled down, and the adjacent strata, long exposed to the heat, would have acquired a certain general induration. If the strata had still been accumulated over the plutonic mass to a great thickness when the latter ceased to reduce them, and been subsequently pared down to

* See account of the rocks of Pulo Ubin, p. 22, Trans. Batav. Soc. Arts and Sc.

their present remnant by denudation, they would not have been broken up in the manner in which we see them to be, but in a mode resembling that in which the great aqueous formations of Europe and America are arranged around or on the flanks of plutonic mountains, and in which the strata of the ancient land may perhaps yet exist in some parts of the flanks of the great intumescence or submarine elevation of the Malayan Archipelago where it rises from the bottom of the Indian Ocean.

12. The prevalent layers and heaps of volcanic-like gravel were not ejected. They are merely the accumulated debris of walls and veins arising from the decomposition and washing away of the softer parts of the containing rock, and remaining by virtue of their ferruginous and jaspideous composition, which resists atmospherical action.

I have found all the forms of the gravel in the places where they were generated,—that is, in the walls traversing the solid or partially disintegrated rocks.

13. The iron was not injected in a fluid state into the strata, as lava is into fissures, but was either imbibed, or, as is most probable, conducted by vapours, gases, or electric currents. The ferruginous and quartzo-ferruginous rocks, *including laterite,* wherever minutely examined, prove to be the original rock of the situs metamorphosed, and not a foreign rock injected from beneath; and there are evidences in all classes of the rocks affected, that the iron, although ascending in abundance wherever the rocks were fissured or weakly coherent, was thence transfused without its exerting any mechanical force, and without the slightest disturbance of the previous arrangement of the particles of the rock*.

14. It is probable that the plutonic rock was not in a molten state up to its contact with the strata, because if it had been, the fissures, which must have been caused by the irregular force exerted on the strata and their frequent disruption, would in that case have given rise to true dykes and veins, *i. e.* those formed by fluid plutonic or volcanic rock being pressed up into rents.

15. The numerous ferruginous dykes which ramify in the plutonic rocks were contemporaneous, because if we suppose them to have been true dykes produced subsequent to the intumescence and consolidation of these rocks, the enormous force, necessary for rending and cracking them in so many directions, would have extended the fissures into the superincumbent strata, and the injected dykes would

* The entrance of the iron was, however, in many cases simultaneous with mechanical strainings and ruptures of the rocks, and, when rising abundantly into the main walls and forced thence into the lateral ones, must have exerted considerable pressure. The mechanical straining and the exhalations were both effects of the same cause, the plutonic intumescence. The only case which I have observed of a direct connection between the matter of the walls and a mechanical alteration in the adjacent rock is seen when quartz is largely developed in lumps in the quartzo-ferruginous dykes. The adjacent unaltered layers are pressed together and bent so as to make room for the quartz. Even here I do not think this is attributable to a large accession of new matter, but mainly to the expansion of bulk attending the conversion of the siliceous particles of the original rock into crystalline quartz.

have been continued into these strata also. The contemporaneity of the ferruginous dykes is further proved by the mode in which they are connected with the adjacent granite in localities, such as the coast of Batam and the Water Islands near Malacca*, where they can be examined in the undecomposed rock.

16. The more highly ferruginous parts of the walls in the plutonic and sedimentary rocks are identical in appearance, the proportion of peroxide of iron which they hold being so great as entirely to disguise the original rock. The peroxidation of the iron tends to obliterate all traces of its original condition, and to give a uniformity of aspect to all the rocks which I have designated as iron-masked†, so that we shall not be able to see in what form the iron exists prior to the exposure of the rocks to atmospherical influences, until we have much deeper sections than are anywhere exposed at present. It is obvious, however, that the effect of decomposition has been to saturate the water in the rock with oxidized iron, and diffuse it more uniformly through the arenaceous and aluminous matter of the walls. If the oxidized crust of the district, which probably descends to a considerable depth, were pared off, the peculiar aspect and structure of the iron-masked rocks would disappear ; the deep rusty, dark brown and black colours, and the scoriform, vesicular, and tubular structure of the walls and lateritic patches, which now so powerfully arrest the attention, would be nowhere recognized, and in place of them we

* Malacca, including Naning, in all its main features, is identical with the district of the Straits of Singapore. All the phenomena of elevation, ferrugination, &c. which we see here are there repeated. See ' Five Days in Naning,' by J. R. Logan, Esq., Journ. Ind. Arch. (for May 1849) vol. iii. p. 282.

† " The interest which the discussions respecting laterite have given to that rock tends to invest it with undue importance geologically. The ferruginous emissions have penetrated all rocks indiscriminately, and their action on sandstones, grits, and conglomerates is as well-marked as that on clays, marls, and shales, although the latter only produces proper laterite. Even in the clays, laterite denotes one only of many degrees and forms of alteration. To express the origin of these rocks, and its unity, to record the cause of the difficulties which they have presented, and to distinguish them from true metamorphic rocks, I would propose, avoiding any new technical names, to term them simply the *iron-masked* rocks of the Indo-Australian regions. This term will include the principal or plutonically ferruginated rocks, which, without being either completely reduced or metamorphosed, have been either wholly disguised or partially altered by ferruginous emissions, which have saturated them in the mass, or only affected them in fissures and seams, or have been interfused between portions of the rocks not actually separated by fissures, but intersected by planes of mere discontinuity, the sides of which have an imperfect cohesion, or having a common border of inferior density and increased porosity, caused either by interruptions in the original deposition of the matter of the rock, or by unequal stretching, or incipient cleavage. The term may be also extended, perhaps, to those sedimentary beds in which the iron-saturation, although coæval with the deposit of the other constituents of the rock, has served to obscure or conceal their true nature as well as the derivation of the beds themselves. These beds appear to have been sometimes formed by superficial layers of gravel, &c. being permeated by iron-solutions. With these must not be confounded the broad bands lying over and beside the heads of iron-masked dykes, and which, having been in a loose gravelly or fragmentary state at the time when the plutonic emissions passed through them, became converted into hard, and occasionally scorious, ferruginated conglomerates, &c., and are therefore proper plutonically iron-masked rocks." (Journ. Asiatic Society (Calcutta), vol. xvi. p. 521.)

should see in the walls of the sedimentary rocks the ordinary matter intermixed with pyrites and other unperoxidized forms of iron-ore, and, in those of the plutonic rocks, similar forms of iron, accompanied probably by a predominance of those common plutonic minerals in which iron is a large ingredient, owing to its accumulation there at the time of the crystallization. The ready decomposition of iron-pyrites would account for the great depth to which the walls and veins have been peroxidized.

17. It is of great importance to determine, if possible, the state in which the iron was originally deposited, and why it was given off so abundantly by the plutonic intumescence. It appears probable that it was volatilized in combination with sulphur.

Is its abundance owing to the ferruginous character of the old land out of which the plutonic rock was formed, and do the highly hornblendic portions of this rock indicate a more than ordinary prevalence of iron in their parent sedimentary rock? The chocolate-coloured shale-band would probably produce such a granite. Sandstone appears along the western boundary between the granite and this shale; but near the present Arrack Distillery (33), where they are in contact, the granite is very ferruginous, decomposing into a dark-red soil, and containing half-decomposed masses approaching to iron-ore.

18. I have searched for the continuation of the ferruginous walls of the sedimentary rocks into the plutonic rocks. Unfortunately the line of junction of the two formations has not anywhere been laid bare, all the points exposed to the action of the waves being exclusively of the one or the other, and the deep superficial bed of earth conceals the undecomposed rocks in the interior. Last year a cutting of a few feet at a point (the south angle of Sri Menanti nutmeg-plantation at the junction of the River Valley and Tanglin roads (39)) where the formations meet, exposed a portion of a stratum of coarse-grained sandstone lying in an irregularly convex form on the decomposed plutonic rock, which appears to have been syenite. This has covered it in some places, and probably the whole or the greater part of the mass was originally imbedded in it. The surfaces are irregular and uneven, but have a general correspondence with the plane of the bed. It varies in thickness, having in some places 4 or 5 feet of well-preserved sandstone, while in others it shows only patches and ferruginous plates in the syenitic clay. It varies from a fine sandstone to a coarse grit, and some parts are conglomeratic. In some places it has been converted into a mass of hard and difficultly frangible iron-ore. Where least altered the rock is hard but brittle; the granules and pebbles of quartz are all preserved, but they have a dull whitish and yellowish colour, and rest in a basis of hydrous peroxide of iron, varying in colour from dark-brown to black. The microscope shows this basis to be not compact but vesicular, fine scales or plates surrounding the quartz-granules and partly filling the interstices between them. Where the clay meets the sandstone, the latter has generally a continuous crust or plate of shining, black, compact ore. Irregular systems of a similar crust are sometimes seen with the clay between them. At other places the whole is cellular, and a perfect

laterite is produced. Sometimes this structure is seen continued from the bed of sandstone into the clay, where the ferruginous ramification and blotches become softer and admit of being cut by the hoe.

In some places the iron has not pervaded the sandstone, but only penetrated it in layers or veins. In these cases it has disintegrated into a soft ferruginous sand. Where the iron has been diffused the sandstone is undecomposable, and remains hard but brittle. This locality exhibits, 1st, solid, compact, shining ore; 2nd, cellular ore filled with decomposed syenite; 3rd, variously iron-masked sandstone and grit.

I have hitherto proceeded on firm ground, but, in extending these deductions much further, must take a direction where many may not be disposed to follow, and where we cannot yet hope to obtain a sure footing. I venture, however, to suggest as hypotheses deserving of deeper investigation the following additional views which my observations strongly tend to support.

Whether the plutonic rocks are simply the product of a heat above the melting-point, or were formed at a lower temperature by chemical and electrical action induced by the heat, the sedimentary rock in contact with and raised upwards by them must have been partially reduced into the plutonic mass. In either case, the upper portion, at least, of that mass is a recomposition of the lower part of the sedimentary rock, with an addition of new ingredients from below; because, so long as the heat was so intense as to produce perfect mixture, agitation, and motion *inter se* of the reduced matter and the plutonic mass into which it entered, the upper limit of the bubble must still have been distant. So long as this level was not reached, each successive portion or layer of the sedimentary ceiling must have passed through similar changes before it became obliterated by complete absorption into the plutonic intumescence,—first becoming affected by the mechanical pressure, and then by the increasing heat and exhalations of the labouring mass below. Therefore, at whatever level the plutonic force, whatever its precise nature may have been, ceased to assimilate the superincumbent rock, this rock, to a certain distance above that level, must have passed through the same stages of alteration, exclusive of the ultimate one, which the plutonic mass in contact with it had itself gradually undergone. Whatever changes we can now observe in the remaining sedimentary rocks adjacent to the plutonic bosses, we may conclude that the *plutonization* of the latter commenced in the same way; and this we may do with perfect confidence, when we find that these changes are seen over a great region. If these postulates be well-founded, the phænomena of the district of the Singapore Straits, which are repeated throughout the whole chain of the Malay Peninsula and its prolongation to Banka and Billiton, disclose to us this fact, that the conversion of the sedimentary into plutonic rocks began with their being pervaded, in fissures and lines of inferior cohesion, with ferruginous exhalations, producing ferruginous walls and veins.

Since in the now solid plutonic rocks we find similar walls and veins, the presumption is that these are the same walls and veins by which the metamorphism commenced. This is a simpler theory than that which would require the process of plutonic assimilation, as it advanced, to have first obliterated those originally formed, and then created a new system so remarkably similar to the old one. In what way could such systems of ferruginous walls and veins have been produced *de novo* in a plutonic mass thoroughly melted down into uniformity? If it were clearly demonstrated as a general theory that plutonic rocks are congealed from a state of fluidity, it might, notwithstanding these and other difficulties attending its application to the rocks of the district *, require us to reject the simpler theory which these rocks inculcate. But plutonic geology is in too imperfect a state to entitle us to assume any general theory as established, and nothing but the assumption that granite is necessarily, everywhere, a product of complete igneous fusion, requires us to suppose that two successive systems of ferruginous walls were produced, one at the commencement, and another before the conclusion, of the plutonic change.

If we are satisfied to suppose that only one system was produced, until some proof be adduced that it could not possibly have remained unobliterated during the plutonic process, these walls and veins become objects of the highest interest and importance, and all the phænomena connected with them demand attention.

I shall only here advert to one, the concentrically laminar coloration, frequently seen on a small scale, and so splendidly developed in Sabaru, Jong, and Bukum. The very same zoned coloration is observable in some of the sections cut into decomposed plutonic rock, such as that where the public road crosses Mr. Hewetson's Hill, where similar zones exist on the sides of a ferruginous dyke. The neighbouring solid greenstone possesses the same structure as this decomposed rock, nests of hornblende, corresponding to the red patches, and hornblendic lines, often very minute, to the curved zones. When we examine the great developments of solid plutonic rock, we find that they present similar phænomena. The granite of Pulo Ubin, for instance, when its coherence is weakened by exposure to the action of the sea, exhibits connected systems of concentric and variously curved laminæ, in which one system is interrupted and modified by another, and accommodates the shape of its curves to it, precisely as we see in those of the coloured lines of the sedimentary rocks.

If we do not adopt the theory of the necessity of granitic fluidity, may we not suppose that, as the plutonic action first invaded the superincumbent strata in the ferruginous walls and veins, it operated principally through them wherever they existed; that even when complete assimilation took place they still remained, however modi-

* Before I had ascertained the connexion between the ferruginous walls in the sedimentary and those in the plutonic rocks, I endeavoured to explain the phænomena of composition and structure presented by Pulo Ubin, in accordance with the theory of congelation. See the 'Rocks of Pulo Ubin,' *loc. cit.* pp. 26 to 40.

fied *; that the concentric ferruginous zones to which they gave birth determined the structure of the ultimate plutonic rock, and, to a certain extent, the arrangement of hornblendic and other ferruginous minerals; and were perhaps the channels by which an electro-chemical operation, emanating immediately from the walls, was made to pervade all the adjacent parts of the rocks, until crystallization was induced, and the metamorphism was complete?

The district, considered as more or less metamorphosed, exhibits two sets of phænomena, one where the ferruginous walls and lines are the principal feature, and the other where they are rare or absent. In the first case the plutonic action appears to have extended to great distances from its place of full operation, and in fact to have had no limit but the length of fissures and planes of discontinuity in the superincumbent rocks. On the other hand it has often been extremely weak, hardly extending beyond the walls, and leaving the adjoining rock unaltered. In the second case the plutonic action appears to have from the first pervaded the whole mass of rock, as far as it operated, and to have produced the following succession of changes, examples of all which occur:—1st. The original rock is indurated in different degrees; 2nd, a subcrystalline texture is induced, but without any perfect crystals being generated; 3rd, crystals of particular minerals begin to appear in this basis; 4th, the same process is continued and various forms of crystalline rock are produced, the granitic being that where the conditions of crystallization were most favourable, either from the longer continuance or greater intensity of the plutonic action. The process when preceded by the formation of ferruginous walls is the same in effect, as these merely tend to determine the manner in which the iron is diffused, the lines where crystallization begins, and particular minerals are generated, the structure in the mass of the regenerated rock, and the distance to which the plutonic action, in its various degrees and with its various results, extends.

It is evident that fusion did not precede crystallization in the progress of change up to the formation of the highly crystalline porphyries of Pulo Nanas, South Point, and many places in the eastern islands, and in the greenstones and other highly hornblendic rocks which are undoubtedly the common dark shale of the District disguised, since the graduation from the one to the other can be traced. On the other hand there is no direct evidence that the granitic form was preceded by fusion, while all the facts we have been considering, particularly the generation of other crystalline forms without fusion and the passage of these forms into the granitic, tend to show that it may be produced without fusion. The truth probably is that powerful electro-chemical action can produce all the effects of crystal-

* In the course of the crystallization of the rock they were probably converted into ores of iron where the iron was in excess. In some walls and parts of walls, and in the lateral radiating zones, where the iron was too thinly diffused to generate proper ores, it would produce a predominance of hornblende, black mica, and other ferruginous minerals.

lization from fusion *, and that the whole series of nether-formed rocks, volcanic and plutonic, may be produced in both modes. It is probable also that wherever an electro-chemical action is so intense as to generate the granitic and other highly crystalline forms, it emanates from a lower region where the heat is so great as to cause fluidity †.

Remarks on the accompanying Geological Map ‡.

The basis is the Chart made from the Surveys of Mr. Thomson and Captain Congalton, published in 1846. The rivers, creeks, and alluvial tracts of Singapore I have added from later and unpublished surveys by Mr. Thomson, which he has kindly allowed me to use; and from the same source I took the great majority of the additions and corrections of the names of localities. The insulation of Tanjong Surat and the rough outline of the estuary of the river Johōr above it are merely from my own observations, and not from a survey. The coast of Batam has not been surveyed. A general outline with some blanks appears on the published chart. These blanks and the names of localities § I have filled in from my own observation, as well as the names of islands to the west of it from P. Blakang Padang to P. Kapal. The Sĭlat Batu Haji I copied roughly from a Dutch chart. The orthography of the Malayan names, which has hitherto varied greatly, has been corrected in accordance with the system which I have lately adopted in the 'Journal of the Indian Archipelago,' as the most simple, uniform, and accurate which occurred to me, after giving much consideration to the subject.

The geological colouring is entirely from my own observations, with the exception of Pulo Pisang ||, Gunong Pulăi ¶, the islets to the N.W. of the Krimuns (Carimons), a few places on the coast of the mainland in the Sĭlat Tambrău, the south coast of the S.E. part of Johōr from Tanjong Stapah to Point Romania, the islets and rocks off that Point, and the coast of Bintang with the islets and rocks off it, all which are from information, and partly from specimens, given me by

* In the crystallization of a molten rock the same electro-chemical action may operate. The process must be greatly similar in both cases. The electro-chemical force segregates minerals and gives a symmetrical structure in spite of the solid form of the rock in the one case, and in spite of its fluid form in the other. The solid form tends to keep each particle of the matter of the rock in the place where it has been deposited, the fluid form tends to keep them all mixed up indiscriminately. The electro-chemical agencies of plutonic regeneration perform their office unshackled by either kind of resistance.

† Fusion is perhaps not necessary to account for plutonic intumescence and the consequent elevation, rupture, and inclination of superincumbent strata. If granitic crystallization is always attended with expansion (see the "Rocks of P. Ubin," *l. c.* p. 38), the amount in a vast plutonic mass like that of the Hindu-Chinese and Malayan Peninsulas, Sumatra, and Borneo, with all the inequalities of degree to which the process is evidently subject, might be sufficient to account for the condition in which the sedimentary remnants are now found resting on it.

‡ The lithographed Map, Pl. XVIII., is reduced from the original map coloured by the Author.

§ Few names except those referred to in the paper appear in the reduced map.

|| See p. 318, *note*. Not included in the accompanying Map.

¶ G. Pulai (2152 feet high) lies N.W. by W. of S. Sakodai, beyond the limits of the map. It forms part of a tract of "Crystalline rocks" running N.W.–S.E.

Mr. Thomson. Long Island to the south of Barn Island I have not visited. It is described in an account of a voyage round Singapore (by Mr. Crawfurd, I think; long ago published in the 'Singapore Chronicle') as sandstone and clay-slate.

The alluvial valleys, running into Singapore Plain from the N.W., have been laid down with much care; and, as Mr. Thomson is well acquainted with the ground, they may be relied on as accurate. Those at the back of the island are also correct, but the exact outlines of the bases of the hills have not been laid down, no land-survey having yet been made of that part of the island, and dense mangrove and other jungles generally concealing the outlines.

Coral-reefs fringe the south-western shores of Singapore Island and the shores of the islands to the south, the northern coasts of Batam, with the adjacent islands, and a group of small islands in Tĭlo' Subong. Isolated patches of coral occur also on the eastern coasts of Singapore.

Explanation of Geographical Affixes used in the Memoir and Map.

Suñge *or* Suñgĕi, *river, stream.*	Tanjong, *promontory.*
Sĭlat, *strait.*	Pulău (Pulo), *island.*
Tĭlo', *bay.*	Malang, *rock above water.*
Tana, *land.*	Batu, *stone, rock.*
Gunong, *mountain.*	Padang, *plain.*
Bukit, *hill.*	Kampong, *a collection of houses.*
Pĕrmatang, *a long elevation.*	Ayĕr, *water, stream.*
Busong, *a spit of sand.*	Paya, *marsh.*

[A few small sections of the rocks of Singapore and the neighbouring islands are given in Journ. Ind. Archip. vol. i., in illustration of Col. Low's "Notes on the Geological Features of Singapore."]

DONATIONS

TO THE

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I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

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II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the Distribution of the Flint Drift *of the* South-east of England, *on the* Flanks *of the* Weald, *and over the* Surface *of the* South *and* North Downs. By Sir Roderick Impey Murchison, G.C.St.S., F.R.S. G.S. L.S., Hon. Mem. R.S. Edinburgh, R.I. Ac., Mem. Imp. Ac. Sc. St. Petersburgh, Corr. Mem. Ac. France, Berlin, Turin, Copenhagen, &c. &c., and President of the Royal Geographical Society, London.

Read May 14, 1851.

[For the other Communication read at this evening Meeting, *vide supra,* p. 257.]

Contents.

Although the tract about to be noticed has for many years been under the consideration of geologists who have well explained the structure of its rocks, and the physical dislocations by which they have been affected, the points to which I invite attention in the title of

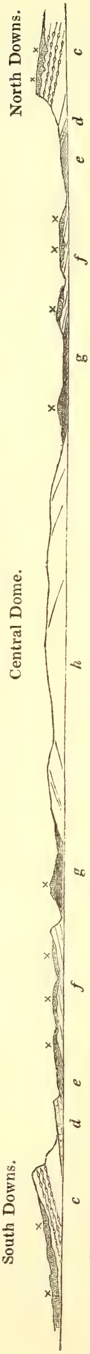


Fig. 1.—*Sketch-section of the Wealden Valley of Elevation, showing the General Relation of the Angular Drift to the Chalk, Gault, Greensand and Weald Clay.*

Extent from North to South about 30 miles.

x. Drift, covering at intervals all the formations excepting the Hastings Sands. *c*. Chalk. *d*. Upper Greensand or Malm rock. *e*. Gault clay. *f*. Lower Greensand. *g*. Weald clay. *h*. Hastings Sands.

this Memoir seem to me to require much more illustration than they have received. Some facts not having been noticed, and others not sufficiently insisted upon, I hope to show, that if we cannot yet satisfactorily account for all the external appearances of a country so near to our metropolis, we may at all events safely withhold our assent to some of the theoretical views which have been employed to explain the modifications of its outlines and the distribution of its superficial covering. At the same time I am quite aware that my observations are far from being complete, even in reference to this limited area, and I chiefly offer them, as well as my theoretical views, in order to elicit further inquiry and discussion.

Denudation of the Central Region of the Wealden.—That the Weald of Kent, Surrey, and Sussex, being a valley of elevation, has also, like most such masses, been powerfully denuded of overlying rocks that once existed in it, was long ago suggested; but the extent to which portions of its surface, lying between the central nucleus and the chalk-escarpments, still retain transported materials upon them has not been adequately stated. Let us first scrutinize the nature of the broken and superficial materials which overlie the formations whose faces or edges have been exposed, and see whether there be drifted matter within the Weald similar to that which has traversed the gorges in the subtending ridges of chalk, and has been so largely spread out on the outer slopes of the South and North Downs.

Viewed on a ground-plan, the Wealden of the South-east of England and the Boulonnais, as surrounded by the Chalk and the younger or tertiary deposits, consists of a succession of ellipses within ellipses, composed of strata successively overlapping one another. The innermost mass of these, or the sandstones and clays of Hastings, is, as far as I know, devoid of all transported matter on its surface (see fig. 1). No detritus of chalk-flints, nor any drift which may have been carried from the higher surrounding ridges, has hitherto been found on the slopes of the hills or in the valleys which pertain to the really central nucleus, designated the Forest Ridge by Mantell, and which extends from Brightling Down and Crowborough Beacon on the west to the sea at Hastings and Winchelsea. Admirable examples of the clean denudation of this central tract are seen at Tunbridge Wells and Hastings, where the bare sandstone stands out in picturesque forms. The valleys of this central region do, indeed, occasionally present local accumulations of re-aggregated clay or loam which has been derived from the contiguous hills; but in these we see no signs of a powerful former drifting agency, by which fragments of rocks foreign to the locality have been transported to it. Nor can I hear that these purely local surface-deposits have afforded any examples of the large extinct quadrupeds, whose relics will be presently adverted to as being distributed at intervals over the adjacent and overlying formations. This coincidence of the absence of transported debris ("terrain de transport") and also of the remains of the great fossil mammals in the central dome is then the first point to which I call attention. It is the more remarkable, because in some of the above-mentioned depressions there are thick superficial accumulations of clay and brick-earth, beneath which, at a depth of several feet, stumps and stems of black oak are found, both in vertical and horizontal positions, just as on the surface of the surrounding formation of Weald Clay, hereafter to be noticed, but where, in addition, there are heaps of drifted chalk-flints or other rocks, together with these bones of extinct animals.

When, however, the observer moves westwards for about fifty-five miles, from the environs of Winchelsea to those of Billingshurst, he sees something approaching to the character of drift upon the surface of the central dome. But even there, where the equivalents of the Hastings group occupy low undulations, and are thinning out to an apex, the only superficial covering which distinguishes them is a loam, that here and there contains lumps of a bog-iron-ore, provincially called 'Rag'*. This rock, which occurs in the ploughed fields or along the banks of the Arun and its tributaries, is an admixture of very rich mottled ironstone with loam, the former in a concretionary and semi-brecciated form. It is difficult to say whether the ferruginous portions of this rock have been at all transported, or whether they are not local accumulations of bog-iron-ore formed in an ancient period, out of the subjacent bands of iron-stone, and before the Wealden was finally desiccated and its rivers reduced to their present limits.

Distribution of the Flint Drift over the surface of the Weald Clay, Lower Greensand, &c. in Hampshire and Sussex.—When we quit, however, the nucleus of the Weald and advance from it either to the south or north, there are many localities in which heaps of flint-drift are found upon the eroded surface of the Weald Clay and Lower Greensand. This fact is the more striking, because, although a spread of flints will be spoken of as occurring at rare intervals on the Gault, the surface both of that and of the Upper Greensand and Lower Chalk,

* My attention was first called to this 'Rag' by Sir Henry Goring, Bart., on whose property near Billingshurst it is pretty copious, and was formerly, as Mr. Martin of Pulborough tells me, worked for smelting into iron, by which process vast quantities of it have disappeared.

which lie between the Lower Greensand and the Chalk with flints, is for the most part exempt from such debris. This occurrence, therefore, of broken flints of the Upper Chalk scattered at distances of two to four miles from the escarpments of the South and North Downs (including the Hampshire or Selborne range in the latter) leads me to speak of it as having been chiefly distributed in a zone, lying between the chalk-escarpments of the South and North Downs and the central dome of the Wealden.

The features of this drift will be first described as they occur under the western end of the escarpments of the South and North Downs, in a district long familiar to me*. There I had been well acquainted, for many years, with the existence of piles of sharply fractured chalk-flints on the slopes of Lower Greensand, or filling eroded cavities on the summits of the hills of that formation between Petersfield, Steep, and Sheet, and which extend by West Heath and Rogate to Trotton and Midhurst Commons on the east. As this band of sandstone is slightly coherent only, it disintegrates to loose sand chiefly of ferruginous or whitish colours, on which, and in the deeply eroded cavities of its surface, the flints are irregularly piled up, at altitudes varying from 50 to 300 feet above the drainage of the little river Rother and its affluents, and void of any signs whatever of stratification. Such flint-drift may indeed be traced in a zone from Stroud Common on the west by the low hills north of Petersfield† to its greatest altitude on the edge of the escarpment of the Lower Greensand overhanging the southern side of the remarkable depression called Harting Combe. There the same debris has been partially carried to the southern side only of the angle of Weald Clay‡ which is there denuded. The consideration of this point will be resumed in the sequel.

In the meantime, the accompanying woodcuts (figs. 2 & 3) will serve to explain the relations which this flint-drift (*x*) bears to the Chalk-hills on the north and south (*c*), and to the inferior formations of Upper Greensand, Gault, Lower Greensand, and Weald Clay (*d*, *e*, *f*, *g*), as they are exposed in the extreme apex of the Wealden denudation near Petersfield. In fig. 2 the spectator is supposed to be looking westwards from the west of Petersfield, where the chalk of the North and South Downs is seen to be confluent near East Meon. I will presently endeavour to show that it is from this western depression and fracture of the Chalk that the flints spread over the surface of the Lower Greensand must have been derived; seeing that they can be continuously traced up to it. On the other hand, the flanking strata of Gault, Upper Greensand or Malm Rock, and Lower Chalk

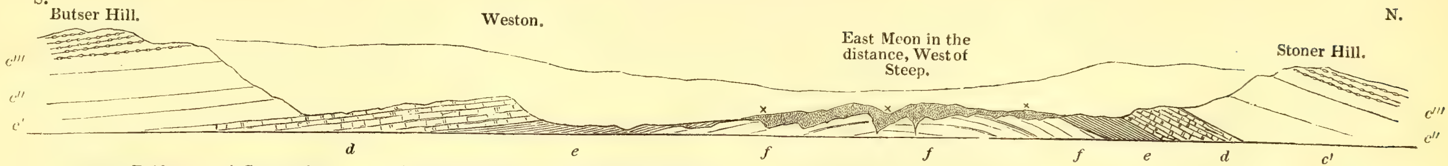
* See Memoir on Parts of Surrey, Sussex, and Hants, Trans. Geol. Soc. vol. ii. N.S. p. 97 *et seq.*, and Map and Section, Pl. XIV.

† The top of the tower of Petersfield Church was fixed by the Ordnance Surveyors to be 254 feet above the mean tide-level of the sea, and I estimate the summit of Rogate Common as probably 300 feet higher.

‡ In my published map, Trans. Geol. Soc. N. S. vol. ii. Pl. XIV., and in all the maps which have followed, the surface of Harting Combe is represented as Weald-clay only; but I have little doubt that if lateral excavations were made, the Atherfield beds with Neocomian fossils would also be found there.

Fig. 2.—*Section across the Western Extremity of the Weald Valley, where the Angular Drift occupies the surface of the Lower Greensand only.*

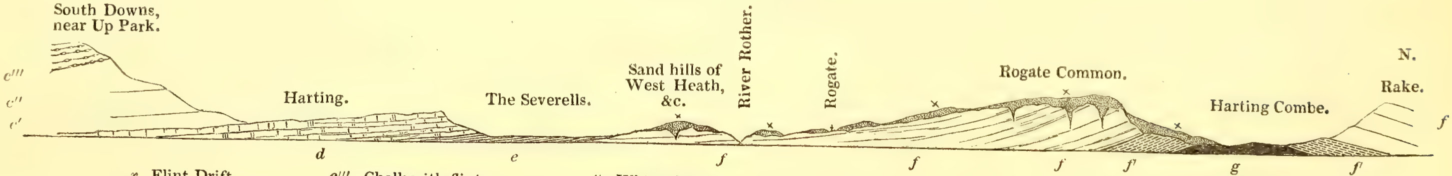
Length about 4 miles.



x. Flint Drift. *c'*. Lower chalk. *c''*. White chalk. *c'''*. Chalk with flints. *d*. Upper Greensand or Malm-rock. *e*. Gault clay. *f*. Lower Greensand.

Fig. 3.—*Section across the Valley of the Weald near its Western Extremity, showing the Relation of the Angular Drift of West Heath, Rogate Common, and Harting Combe to the Lower Greensand Rocks.*

Length about 6 miles.



x. Flint Drift.
e. Gault clay.
c'''. Chalk with flints.
f. Lower Greensand.
c''. White chalk.
f'. Atherfield beds ?
c'. Lower chalk and marl.
g. Weald clay.
d. Malm rock or Upper Greensand.

(*c*, *d*, & *e*) being free from such debris, it is a natural inference that the flint-drift has not passed from the subtending chalk-escarpments. Near Petersfield chalk-flints alone constitute this detritus; but in moving eastwards to Rogate and Trotton we find that portions of hard ironstone, the clinkers or car-stone of the Lower Greensand, as well as chert of that formation, are added to the mass. In the environs of Trotton, Midhurst, and Petworth, where the formation has expanded, clinkers and chert are indeed near at hand, *in situ*, from whence the additional materials could have been derived.

In recently extending my researches eastwards to the district around Pulborough, under the guidance of my friend Mr. Martin, who has so ably illustrated the physical structure and dislocations of the rocks around his residence*, he pointed out to me how the detritus of the Lower Greensand was often arranged in East and West ridges (locally termed 'rigs'), which lie indifferently upon various strata, often intermixed with angular chalk-flints and some chert. As in the sand-hills near Petersfield and at West Heath and Rogate Common (fig. 3), the detritus around Pulborough is distributed at various altitudes, and is everywhere unstratified.

In going eastwards from the drainage of the Arun to that of the Adur, the lower grounds occupied by the Weald Clay are seen to rise into eminences on either side of the high-road from Horsham to Worthing, and it is just upon the slopes or summits of these elevations between West Grinstead and Ashington that Mr. Martin pointed out to me irregular heaps of shattered chalk-flints more or less angular, which are mixed up with pieces of the ironstone, or "clinkers," of the Lower Greensand and some chert of that formation. These fragments are disseminated through re-aggregated loam, and here and there they combine to form rocky lumps of "ragstone," or a compound breccia.

It is curious to observe how the chalk-flints, which have been for so many ages deposited upon formations quite foreign to them, have partaken of the colours characterizing those strata. Thus, whilst on the white sands of Trotton Common most of the flints are either white or grey, those which have been long buried amid surface-heaps of ferruginous sand around Petersfield, Rogate, and Pulborough have become ochreous or yellow, whilst some of those which have been arrested in the Wealden clays between Ashington and West Grinstead have passed into various shades of deep red and purple, colours which penetrate the whole mass, and are doubtless due to the modifications produced by the infiltration of water charged with the ores of iron.

In following this irregular band of drift eastwards until we reach the sea, chalk-flints are found at intervals only upon it; but in its range from West Grinstead and Ashington on the west, to the district north of East Bourn, it is more specially distinguished by a more or less copious admixture of loam, by which the cold and sterile character

* One of these memoirs was unluckily mislaid for a long time at the Geological Society, owing to which some good original observations were lost. See Geological Memoir on a part of Western Sussex, 1828, and Observations on the Anticlinal Line of the London and Hampshire Basins, Phil. Mag. 1829.

of the subjacent clay is neutralized. Good crops of corn are thus visible along this argillaceous zone, which otherwise would be occupied by oaks only, or by weak grass. To the north of Lewes the drift-zone is specially marked in the parish of Barcombe, by exhibiting many chalk-flints, long ago well described by Dr. Mantell; and, as the fact has been cited by Sir Charles Lyell as the only exceptional case to the usual clean denudation of the Weald, I lately visited the spot.

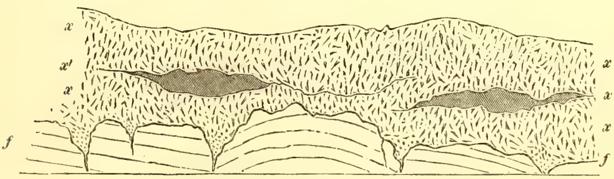
The slopes and summits of the low undulations of the Weald Clay at Barcombe are more or less covered with the usual brownish-red loam and clay, in which flints, more acted upon by water than those near Petersfield, and stained with various colours, lie at heights of 120 to 200 feet above the sea, and, as in the localities above cited, are irregularly disseminated without any appearance of stratification. In short, from Petersfield to East Bourn, where the drift becomes for the most part an accumulation of clay or loam, I have nowhere seen it exhibit signs of successive bedding; but everywhere proofs of its having been accumulated suddenly and tumultuously, whether it be lodged on the Lower Greensand or on the Weald clay.

Now, whilst the central dome of the Lower Wealden is, as before said, void of all such drift and also of all extinct fossil mammalia, the zone I have described is more or less characterized by them. Near Petersfield, where the flints are not protected by any capping of loam and clay, it would be hopeless to expect to find bones, which if exposed for ages to the percolation of water must have perished. But in the depressions south of Petworth near Burton, where they were mentioned by Dr. Mantell, and at Hurston or Wiggenholt, remains of fossil quadrupeds have been found under loam, including teeth of an Elephant at the latter place*.

At East Bourn, where the eastern extremity of this zone of drift consists chiefly of clay and loam, a harvest of fossil mammalia has been for many years obtained, and from it Dr. Mantell has already cited *Elephas primigenius*, *Hippopotamus*, *Cervus*, &c.

In the sequel we shall have to consider similar accumulations of fossil mammalia on the northern side of the central dome and under the escarpment of the North Downs. The woodcut, fig. 4, may

Fig. 4.—*Diagram, showing the general Disposition of the Angular Drift when not covered by Clay or Loam.*

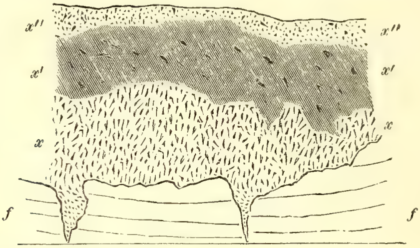


x. Drift (chiefly flints with some clinkers).
x'. Intercalations of uniform fine sand in the drift.
f. Lower Greensand or other rock.

* Mr. Martin showed me specimens of some of these when I last visited Pulborough.

serve to give an idea of the prevalent arrangement of the materials of the drift on the surface of the Lower Greensand and other formations where no clay occurs; whilst fig. 5 represents examples where much

Fig. 5.—*Diagram in illustration of the Arrangement of the Angular Drift, as it occurs with animal remains.*



x''. Loam with many flints.
x'. Argillaceous loam with few flints only.
x. Flint drift, lower part, composed of angular debris.
f. Inferior formation, whether Chalk, Lower Greensand, Wealden, &c.

clay (usually overlying the mass of angular flints) has preserved the bones of animals in the drift.

In speculating upon the former causes which might have distributed the debris in the irregular manner above described, at such various heights and so completely out of the reach of all rivers ancient or modern, my first general impression was, that these angular flints were simply the subsided residue of the enormous masses of Chalk that once covered the inferior formations. But this is no explanation of the facts; for if such had been the case, why should there not be as much flint-detritus on the Lower Chalk, Upper Greensand, and Gault, as on the Lower Greensand? Again, why should the surfaces of the three last-mentioned deposits not be eroded in the same manner in which the Lower Greensand is affected? We must therefore seek another origin for this zone of the flint-drift. Looking to the western extremity of the tract of Lower Greensand, where chalk-flints, as above said, alone prevail, I am disposed to suggest, that they were chiefly transported to the hills of sandstone where they now lie, from the recess of Langrish, west of Petersfield, where the chalk which unites the North and South Downs has been extensively denuded in reference to the "hangers" or escarpments of the same formation on the flanks. There, indeed, a very slight elevation separates the sources of the Rother (which, flowing eastwards by Petersfield, falls into the Arun) from those of the river Aire, as fed by its purely Chalk-affluents in the valley of East and West Meon (see fig. 2, p. 353).

Viewing the extensive denudation of the chalk in this angle, and the heaps of flints which are spread out over Stroud and Steep Commons, we may infer that this was the tract whence the debris was translated from west to east; for in following that direction we have other indications that such was the case. Near Petersfield *chalk-flints only,* as I said, are met with, and when we look to the west we see the reason why. In the apex to which the Greensand is reduced in this situation, there are no courses of clinkers, nor any escarpments of the formation whence such materials could have been derived. After passing, however, the hills of Trotton, Midhurst, and Petworth, in which clinkers abound, we can easily understand how a drift or current, acting from west to east, should have merged its chalk-flints with debris of the harder beds of the sandstone over which it passed, and have also translated fragments of chert from the still lower and well-exposed inferior member of the same formation. This view supposes, that the movements which fractured the rocks along this western portion of the great anticlinal of the Weald were accompanied by a sudden rush of waters.

The loftiest position occupied by the flint-drift to the east of Petersfield has been already alluded to as the summit of Rogate Common, about 500 feet above the sea, where the Lower Greensand forms the southern flank of the deep denudation of Weald Clay in Harting Combe (see fig. 3). By consulting the geological map I formerly published*, the reader will see that the Lower Greensand there subtends the Weald-clay at a sharp angle, the point of which is precisely directed to the angle of confluence of the chalk, whence this flint-drift is supposed to have proceeded. The flints which lie on the summit of the escarpment have been chiefly shivered to small angular fragments, and intermixed with detritus of the rock *in situ*; but larger flints and in greater quantities have been carried down the sides of the southern escarpment and advance over undulations of the Lower Greensand to the edge of the clay in the deepest part of the depression. In trending the northern and north-western sides of this deep combe, the geologist can, however, detect no flint-detritus; the sand-rock being everywhere at the surface. This is well seen on the edge of Rake Common, along which the London and Portsmouth road passes, and which overhangs the picturesque Harting Combe.

This portion of the escarpment has been quite excluded from the drift; but immediately to the south of the public-house called the "Jolly Drovers," the zone of broken flints is met with, and is seen to descend into the combe, and to keep to its southern side only, under the escarpment before alluded to (see fig. 3). Much of the drift has doubtless passed to the south side of the combe by a marked aperture in the ridge of Lower Greensand, caused by a rupture of the strata in the acute angle into which the formation is there thrown. Now this break and depression at the very apex of the Lower Greensand, and where the strata are highly inclined, point directly to the greater break and depression in the chalk west of Petersfield.

In these phænomena, and in the fact that no *trainée* of flints can be traced from the nearest chalk escarpments, or those of Hawkley Hills across Rake Common, whilst a zone of such is distinctly traceable along the southern side of the great Wealden anticlinal, we have, I think, good grounds for believing, that the drift in question proceeded, as before said, from the angle of fracture and denudation of the

* See Trans. Geol. Soc. Lond. N. S. vol. ii. Pl. XIV.

chalk to the west of Petersfield. It is important to remark that in the longitudinal parallel valley of Gault-clay (see fig. 3), as in the deepest part of the Weald-clay valley, there are no accumulations of drift. Several also of the long slopes of the Lower Greensand are exempt from it. The debris is, in fact, more seen on the summits of the hills of that formation, whether they be 50 or 300 feet above the level of the present drainage ; and in all such situations the surface of the rock has been powerfully eroded, and the flints lodged in its eroded cavities. We must also recollect, that the summit of Rogate Common is much higher than the opposite plateau of Malm Rock or Upper Greensand, which has been so clean swept of all such fragmentary matter (see fig. 3). In all these facts I can only recognize the results of an agency of vast intensity, and clear proofs of a great force that drifted the flinty materials in this district from west to east.

To the east of the tract ranging from Petersfield to Midhurst and Petworth, the reader may see, on reference to the Ordnance Survey, how the elevations of the Weald-clay between West Grinstead and the gorge of the Arun must also necessarily have arrested large portions of these materials in the manner already described. We may therefore, I repeat, suppose that a current translated this debris and swept generally along from west to east, gathering fresh materials from the harder parts of the subsoil over which it passed, and that it traversed promiscuously low hills and dales, in this case along the chief line of the existing drainage, but at great heights above its present level.

Other facts favour the inference, that a former powerful but transient current denuded the surface of the bare rocks in many parts, and at the same time distributed broken materials along a zone of limited width, and, on the whole, in a depression between the Chalk Hills of the South Downs on the one hand, and the central ridges of the Lower Greensand and Weald on the other. The escarpments of the Chalk, extending from Butser and Buriton Hills on the west to the Arun on the east, are nowhere broken in upon by any transverse split, not even by any depression. Throughout this space the Chalk with flints or Upper Chalk is so much thrown over to the south, that no flinty bands now *in situ* are anywhere within the influence of waters, which, having reference to the existing outlines, could transport any materials from them into the valley on the north. In truth, the whole of the escarpment between Butser Hill and Duncton Hill* (the former 872 feet above the sea) is clearly exposed in all its parts, with the Grey Chalk rising from beneath the White Chalk, and on few portions of it, or of the broad plateaus of Upper Greensand and valleys of Gault which lie to the north, are any flints visible. The respective rocks are everywhere near the surface, and void of any quantity of debris, as shown in fig. 2†. In the westernmost tract,

* See Map of the Government Survey, and Section, fig. 2.

† At Harting, near Petersfield, there is, indeed, strong reason to believe that the Chalk has undergone a special amount of degradation at no remote geological period ; for the most remarkable projection of that formation is there seen in the peninsula (almost an outlier) called Tarbury Hill, which exposes the chalk-marl,

the heaps of those flints, all highly fractured and unrolled, are thus confined to the low hills of the Lower Greensand only, neither extending southwards over the intermediate formations to the base of the Chalk Hills, nor occurring on the higher ridges of the same formation in North Heath, Holder Hill, and the hills of Petworth. The mass of flint-debris in the south-western part of the Wealden denudation has thus a width varying from one to two and a half miles, and is presumed to have proceeded from the west. The same phænomena described near Petersfield are seen near Pulborough, where the ferruginous or Upper member of the Lower Greensand has been deeply eroded, and the flint-debris lodged in its cavities on the summit of Fittleworth Hill, as well as in the synclinal slopes of the Gault of Trip Hill—points to which Mr. Martin directed my notice*.

In the environs of Pulborough, the numerous anticlinal and synclinal flexures into which the strata have been thrown, as well described by Mr. Martin, tend naturally to explain why a great amount of debris (particularly of the Lower Greensand) should there be found. The local and unrolled character of such surface-accumulations will also presently be well accounted for by reference to other ruptures of the Chalk. It will also soon be made manifest, that the chief debris accumulated between the central dome of the Weald and the Chalk escarpments, is of the same age as that which is seen at intervals on the sides of the transverse valleys in the Chalk and is spread in such vast quantities over the external slopes of the South Downs.

Anticlinal in the South Downs.—An anticlinal which Mr. Martin has traced from near Midhurst on the west to the Chalk-range east and south-east of Lewes must be taken into consideration in explaining the denudation of the depressions along which it passes, and in accounting for additional heaps of detritus which have been thrown to the right and left of it. Such signs of shedding of the debris of the Lower Greensand to the north and south of this line of rupture are well seen to the south-west, south, and south-east of Pulborough; and the result is, that in this district the debris of the western drift

grey, and white chalk regularly overlying the Upper Greensand in this very narrow north and south counterfort of about three-quarters of a mile in length, and from which the Chalk with flints has been entirely removed. I confess that the synclinal form of this narrow mass of chalk (which is separated from the main escarpment by a deep notch) once impressed me with the idea that it was a remnant or spur of the formation which had resulted from a transverse movement of oscillation, which failing to produce a cross rent or valley had left a north and south ridge as a memento of the force employed. The slightly broken condition, however, of the strata and the other facts previously alluded to compelled me to abandon that hypothesis, the more readily as there is no *trainée* of flints extending from Tarbury across the plateau of Malm Rock and valley of Gault to the sand-hills of West Heath, &c. See fig. 3, and Geological Map of parts of Hants and Sussex, Trans. Geol. Soc. Lond. *loc. cit.*

* Near Pulborough, although the chalk-escarpments are quite free from the flints, Mr. Martin assures me that they occur with some drift-loam, and a few flints in patches, on the Upper Greensand and Chalk Marl. This is a highly dislocated tract. In all the western tracts, the occurrence of a few scattered flints on the mere soil of the Malm Rock and Gault is a rare occurrence, and in no instance do they enter into erosions of those rocks or form heaps of drift.

is in part brought nearer to the Chalk-escarpment than in the environs of Harting and Trotton.

Whether this anticlinal line be divisible into two parallels, as represented in the map of Mr. Hopkins*, or constitute one oblique line of fracture, as Mr. Martin believes, it is enough for my purpose to show how some of the most remarkable collocations of highly angular and sharply fractured flints have a close reference to it, whether we examine the environs of Brighton or those of Lewes; seeing that it passes to the north of the former and the south of the latter place.

The great disturbance of the Chalk near Lewes (long ago pointed out by Dr. Mantell), as well as the persistence of this anticlinal towards the east, is indicated clearly in the longitudinal valley which lies between the Ouse and the village of Glynde. It is completely denuded of all drift, the strata being there clearly arranged in an anticlinal form, and thus constituting a valley of elevation. In considering the manner in which the drift has been accumulated in the Valley of the Ouse, the important part played by this subsidiary valley of elevation will be presently noticed. Let me only say, that if the flint-drift before alluded to on the Weald clay at Barcombe be also referable to this fracture in the chalk, there is just the same difficulty in comprehending its translation thither without leaving some connecting features between its original site in the adjacent escarpment and the spot on which it now lies, as has been adverted to in the cases of West Heath and Trotton Common.

Detritus on the sides of the Transverse Valleys.—Each of the four transverse valleys, by which the Arun, the Adur, the Ouse, and the Cuckmere escape from the Weald through the Chalk to the sea, exhibits ancient mounds of drift, more or less similar to what has been described, arranged irregularly and at different altitudes upon their banks, from 20 to 100 feet above the present rivers. A glance at any of these materials at once bespeaks the tumultuary nature of their origin; for none of them contain rounded or water-worn pebbles. At Peppering, about 80 feet above the Arun, and midway in the gorge of the chalk, bones of an Elephant were found, as cited by Dr. Mantell.

In the defile of the Arun the promontories of North Stoke and South Stoke are just in such relative positions as we may suppose would have arrested or thrown off to the opposite sides masses of detritus hurled along the valley; and Peppering, being in a bay opposite to the round promontory of Arundel Park, is therefore a spot where we might look for a collocation of drift with bones. The more open and straighter chalk-valley of the Adur with no marked promontories or masses was little likely to arrest much drift, which has chiefly been translated to the sea-board.

If no fossil remains have been detected in the valley of the Cuckmere, it is probably because no cuttings have been made in that sequestered tract. There I observed, however, mounds of loam and sand with broken chalk-flints extending southwards from the zone of Weald Clay at Arlington and the station of Berwick to the gorge

* See Trans. Geol. Soc. Lond., N. S. vol. vii. Pl. I.

south of Alfriston, at which place large blocks of tertiary grey-wether-sandstone also occur as boulders.

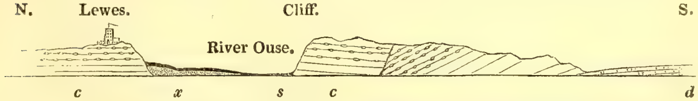
These heaps of detritus occupy low hills considerably above the present drainage, and in their irregular distribution and unstratified aspect resemble the drift of other districts alluded to.

My notion therefore is, that when one portion of the Wealden drift was swept along from west to east in a depression between the South Downs and the elevations of the central dome, other portions of the same were deposited in these gorges.

In the example of the river Ouse, it is indeed probable that the collection of drift to the south of the Lewes Castle Ridge was much increased by the debris thrown into this recess by the operation of the anticlinal elevation before alluded to. The position and relation of this Lewes drift are much too remarkable not to be specially noticed; the more so, as it is owing to the railway cuttings that details have been laid open which were less perfectly seen when Dr. Mantell gave so deep an interest to every feature around his native town*. No transverse-flowing river, which escapes from the Weald through the South Downs, passes through so narrow a gorge of the Chalk as the Ouse at Lewes, the ancient castle being built upon a promontory of that rock, which running from the main mass of the formation on the west, advances to within a very short distance of the hill called "Cliff," and where the abrupt face of the chalk so clearly demonstrates that the gorge has been formed by a great transverse rent. The face or side of that chalk promontory is too abrupt to have permitted the accumulation of foreign drift in any quantity, but the moment the observer has passed the gorge, he sees a wide and flat alluvial ellipse, subtended on all sides by sloping chalk-hills, which, separated in one part by a distance of nearly two miles, approach closely again at Rodmill and Itford. Thence the river once again flows in a gorge, much more open than that of Lewes, and again the valley opens to some width between Newhaven and Seaford.

Now, the chief accumulations of drift occur precisely where one might best expect to find them. First, in the recess in the chalk on the right bank of the Ouse and immediately south of the Castle of Lewes and the tunnel of the London railroad (see fig. 6). There,

Fig. 6.—*Diagram, showing the Position of the Angular Drift and its overlying Argillaceous Loam in the Chalk-valley at Lewes.*



x. Drift and Combe-rock (with Fossil Mammalia), covered by argillaceous loam.
s. Silt. *c.* Chalk (upper and lower). *d.* Chalk-marl (axis).

the angular flint-drift has been cut into to a depth of from 12 to 15 feet, and is covered by a thick mass, as unstratified as itself, of

* See The Fossils of the South Downs, or Illustrations of the Geology of Sussex, by Gideon Mantell, F.L.S., G.S. &c. 4to. London, 1822.

heavy argillaceous loam, in parts used as brick-earth. The highly fractured condition of many of the flints and their admixture with sand, loam, and chalk-debris produce here and there excellent samples of the so-called "Combe Rock," which under that name is now much used as ballast for the railroads. It is here a rusty-coloured mass, owing to the flints having been mixed up with ferruginous detritus of other rocks chiefly tertiary; whilst at Brighton, the chalk itself being the chief matrix, the "Combe Rock" is mostly of a whitish tint. Many of these flints, so entirely fresh-fractured and unrolled, were, I believe, suddenly translated into this recess from the north side of the anticlinal before spoken of, the line of which is only about one mile to the south of this copious accumulation, in which the railroad-termini of the trains to London, Brighton, and East Bourn are established. The high inclination to the north of a mass of chalk with flints, in the southern part of the "Cliff" promontory at Southerham on the left bank of the stream, and which ought, if undisturbed, to have been inclined to the south, is at hand to explain, that many of the angular flints were most probably added to the accumulation in this manner from the reversed rocks. Their present stained and party-coloured character is doubtless due to their having been long imbedded in a mixture of ferruginous sand or clay, probably derived from the breaking-up of the red and ochreous beds of the tertiary Plastic-clay.

I would here beg the reader to remember, that the position of an underlying flint-drift and an overlying heavy clay or loam, which rises to heights of about 40 feet above the Ouse, is exactly analogous to what I shall have hereafter to dwell upon at other places where the remains of fossil mammalia have been found in the lower detritus. Dr. Mantell authorizes me to say that fossil bones have been recently found in this debris of Lewes. He has also formerly stated that the low grounds of the flat expanses of the Valley of the Ouse were occupied by the sea at no very remote period, and have passed from salt-marshes into desiccated lands; so that here, as elsewhere, we have the clearest distinction between ancient Drift and modern Alluvium.

In passing across the Lewes anticlinal to the south, the chalk, on both banks of the transverse-flowing Ouse, is seen to dip gently to the south, near Rodmill and Itford. Thence to Piddinghoe, the summits of the chalk-hillocks *in situ*, which flank the stream, have been largely eroded and their surfaces and cavities have been filled with the angular flint-drift, mixed more and more with reddish loam as you advance to the south, or into the zone where the older tertiary deposits once covered the Chalk. The whole of the sides and summits of the Chalk-hills then present an appearance wholly unknown in the districts of pure Chalk nearer the escarpments, and where no anticlinal disturbance has acted; for the red loam and flint-detritus are very frequently at the surface. This great feature of the Drift will now be considered.

Drift on the Southern Slope of the South Downs.—When the southern slopes of the South Downs are surveyed from Beachy Head on the east to Portsdown Hill and the Forest of Bere on the west, their surface is found to be prodigiously eroded. With the exception of the well-known case at Newhaven, and one which will afterwards be mentioned, the overlying Plastic-clay with its grey-wether-sandstone and rounded pebble beds, has either been swept away, or so re-aggregated and mixed with a tumultuous drift of chalk-flints, for the most part angular, that it can nowhere be said to be *in situ*.

The slopes of the Chalk Hills on either side of the Valley of the Ouse, where they approach to the coast, are here and there laden with considerable thicknesses of the Clay, whether to the west of Seaford or to the east of Newhaven. In many spots the clay merges into loam, in parts quite sandy; in general the tint of the re-aggregated mass is rusty brown and ochreous, owing to a copious dissemination of iron-ore.

The cliffs exposed to the action of the sea afford numerous sections (as seen in the works of Mantell), where the drifted materials enter far into crevices and holes in the White Chalk. In the district comprising the villages of Rottingdean, Falmer, and Stanmer, there are abundant proofs of this infilling of the surface of the chalk, of which, indeed, the cuttings of the railroad from Lewes to Brighton afford numberless examples, some of which, when carefully examined, may be found to pertain to the older tertiary period; though I think these will prove to be rare exceptions. At Rottingdean, the manner in which the angular flint-drift has been swept into the little combe in which the village stands, and where it forms a coagulated mass extending to the sea-front, at once explains, in my opinion, the origin of the East Sussex word "Combe Rock," first used geologically by Dr. Mantell. That author* has rendered the cliffs of Brighton classical by his faithful and lively delineation of this "Combe Rock" or "Breccia," which he also termed the "Elephant Bed," from finding in it abundant remains of these and other extinct mammals.

If, however, in addition to the chalk-flints, we substitute tertiary debris for the fragments of the Lower Greensand, such combe-rock is quite analogous to the "flint-rag" of the Weald already described. A large part of the town of Brighton is built on it. This breccia is there made up of chalk- and flint-detritus, mixed in some parts with sand, in other parts with stiff plastic-clay, and in others with loam. When Dr. Mantell wrote his earlier works, cliffs of this ancient concrete were visible, resting on ledges of solid chalk, and extending from the Steine to Kemp Town: these I have formerly examined, but they are now built up with artificial concrete to prevent subsidence and decay. To the east, however, of this grand parapet, i. e. immediately beyond Kemp Town, the natural features remain well-exposed. They can still be thoroughly examined by walking on the shingle from the end of the Terrace at Kemp Town under the natural cliff (70 to 80 feet high) to the flag-staff of the Preventive Station. There, at the base of the cliff, the white chalk with some flint is *in situ*, and lies in strata which, although nearly horizontal, rise a little towards the east, so as to be about six feet above the higher shingle of the shore.

* See 'Geology of Sussex,' p. 277 *et seq.*, and plates 4 and 5.

Here, however, a new feature presents itself, in the surface of the chalk not being deeply grooved and eroded as it is wherever the drift is immediately superposed to it, and in its being separated from the drift by beds of pebbles, each of which has a thoroughly rounded and water-worn aspect. The pebbles, which are very regularly stratified, in layers with sand, are hardly to be distinguished from those now accumulated by the action of the sea, like which they contain here and there a large fragment of chalk, and occupy a thickness of about 8 or 10 feet. It is manifest, therefore, that they were formed under tidal and wave influences of a former epoch. Dr. Mantell, indeed, suggested this, and also pointed out that this pebble- or shingle-bed contained fragments of granite, porphyry, greenstone, quartz rock, and greywacke-slate, &c.—detritus now foreign to the coast. Again, from the condition of the pebbles and the presence of some marine shells of existing species (together with portions of a whale, *Balæna mysticetus*, afterwards discovered) he very properly deduced, that the beds must have been aggregated by long-continued action of waves,—the more so as fragments of chalk among them had been perforated by *Pholades*. Here, therefore, we have distinct evidence of a true old beach, which, although subsequently raised up, had been tranquilly and naturally formed upon a bare chalk shore during a long period, just as the present shingle is accumulated, at a lower level, on the reefs of chalk seen at low water. It is also to be noted that Dr. Mantell further detected in this old marine shore-bed, some remains of the same quadrupeds which occur much more abundantly in the overlying "Elephant-breccia."

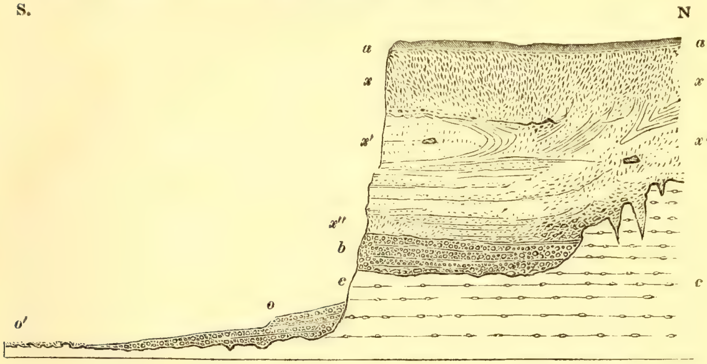
This raised beach has here, however, but a small persistence inland; and its termination eastwards on the coast, which is a little beyond the Preventive Station, is distinctly seen in the vertical cliff.

For the space of the half-mile where it is exposed, the old beach is everywhere immediately covered by drift, which, from its brecciated and tumultuous condition, presents the most lively contrast to the former, see fig. 7. The lower part of this detritus at Kemp Town is in one part made up of large fragments and angular pieces of chalk, almost *in situ*, and confusedly heaped together, with some flints, indicating that they must have resulted from violent dislocation. The mass above these consists in some parts of a whitish, chalky admixture or broken rubble, in which a rude undulation is seen, accompanied however (when viewed as a whole) by numerous convolutions of every sort of irregularity, whether as regards the materials or the contour of the laminæ. Farther east, these appearances are very prevalent, where the mass, particularly in its upper part, has a yellow sandy matrix, and where the thickness is not less than 50 feet. At Kemp Town, for example, the re-aggregated beds have been formed chiefly out of the detritus of the chalk, but towards the Preventive Station they consist, to a great extent, of sands (with a few large fragments of grey-wether-sandstone) derived from the Tertiary Rocks*. This

* Since the observations recorded in the text were made, a fall of a portion of the cliff, about 300 paces east of the walks at Kemp Town, has laid open a clean vertical section of the lower part of the drift which lies on the ancient raised

is the condition of the breccia in the cliffs east of Brighton, and the animal-remains occasionally found in it are chiefly the teeth of the

Fig. 7.—*Diagram showing the general structure and composition of the Brighton Breccia or Combe Rock, and its relations to the Chalk and the ancient and recent Sea-beaches.*



a. Alluvial soil
x. Upper flint drift.
x'. Irregular courses of sand and blocks of grey-wether-sandstone.
x''. Lower drift; in parts a very coarse chalk-rubble with some flints, in parts fine laminæ of sand and chalk-rubble.
b. Old raised beach, with rounded pebbles.
c. Chalk with flints.
o. Present sea-beach and shingle-slope.
o'. Chalk exposed at low water, with pebbles accumulated around large fragments of chalk, as in the old beach, *b*.

Fossil bones are found at intervals in *x*, *x'*, and *x''*.

Horse, Stag, and Mammoth, and such of the harder bones as were capable of resisting the violent commotion which obviously attended

beach. Instead of being made up of large subangular fragments of chalk, as in some places, it is there composed of finely levigated alternations of yellowish sandy and whitish chalky materials, which for a short space are horizontally stratified, although the imbedded flints are angular and unrolled. A little further eastward these fine yellow layers are observed to pass (in the very same horizon, or immediately over the raised beach) into a very coarse white rubble, containing large fragments of chalk, and free from all sand or clay. In other parts of the cliff, irregular layers of sandy and loamy detritus, with some flints, have assumed fantastic forms, resembling those of the contorted and broken drift of the Norfolk coast. Whilst it is specially to the upper and unbedded portion of these loose materials, whether composed of flints or clay and sands with flints, that my observations apply, I must say, that, after examining many sections in a variety of districts, I cannot see by what means this drift can be separated into distinct ages. The organic remains which it contains are of the same species in all portions of the deposit, and, if we seek to distinguish the upper from the lower member by physical tests, we meet with the following result. The apparent separation visible in one place is not only evanescent in another, but the parts, supposed to be distinct, inosculate with and graduate into each other. In one locality the clay or brick-earth overlies all the flints, in another it ramifies through them, and is distributed with patches of sand in the most capricious manner. In addition to the numerous sections mentioned in the text, I may be permitted to state, that excellent examples of this irregular distribution are exposed on the sides of the

the formation of this deposit. The proof of such violence is exhibited in the sharply fractured condition of the flints which are mixed up in the breccia. Not one is rounded, whilst most of them are sharply fractured as if by some sudden tangential force. The proximate cause of their being so unrolled when drifted into the Brighton depression was, I doubt not, the splitting-up of the adjacent chalk to the north of the town by the anticlinal line before alluded to, and which passes from Pie Combe into the depression of Falmer, there separating the chalk of Newmarket Hill, Ovingdean, and Brighton from that of Lewes Race Course and Plimpton Plain.

Before the town of Brighton had increased in a northerly direction, this drift or breccia was seen to extend in the depression between the chalk-hills in which the road to London runs. A like position of the materials occurs at the east end of Kemp Town, where the hollow in which the gas-works are placed is also occupied by rudely stratified alternations of masses of sharp flints, with small rounded fragments of chalk, and yellowish sandy loam with flints. In truth, the Gas Company drove a tunnel through this detritus, for the purpose of bringing coals on an incline from the shore to their establishment; and, although it is now not used as such, and is blocked up at the northern end, any one may still walk into this tunnel for thirty or forty paces, and thus examine on either side the nature of the lower portion of the breccia, which is there very chalky.

Thanks to the former labours of Dr. Mantell, nearly all the animal-remains of this accumulation are well known. Those noted by him are *Elephas primigenius*, *Equus fossilis*, *E. plicidens* (Owen), *Asinus fossilis*, *Bos*, *Cervus*, &c. In addition to these I procured last autumn some very perfect teeth which Dr. Mantell has referred to *Rhinoceros tichorhinus*. I may here mention that these remains of *Rhinoceros* were found in the chalky rubble through which the above-mentioned tunnel was cut, and under about 25 feet of superjacent unstratified flint-breccia (in which however other bones were found). They were accidentally disinterred by the workmen who were cutting new walks from the top of the cliff to the shore east of Kemp Town, and who, using this tunnel to take their meals in, had, in excavating a hole in its side to hold their food and utensils, detached the remains in question. The same men, whose progress I watched, had previously procured for me remains of Horse's teeth and Stag, but the better-preserved bones of the *Rhinoceros* were low down in the softer chalk-rubble, the others in the overlying and more flinty chaotic mass.

It has before been stated, that similar fossil bones occur within the Wealden denudation and in the transverse gorges which proceed from it, and therefore it is not to be wondered at that they should also be discovered at different localities and at different heights up to a cer-

Brighton Railroad near Portsmouth, and still better on those of the South-Western Railroad between Romsey and Salisbury, particularly near the station of the latter place. It would require countless diagrams to indicate the changes of this drift, and I can only express my conviction, that all the portions of it which seem to be distinct are simply the results of operations of the same sort during the same period of violent and turbulent action.—[October 1851.]

tain altitude on the outward slopes of the South Downs. Thus, Dr. Mantell had observed them at Copperas Gap, a short distance inland of Shoreham. I have also to thank the same author for informing me that many years ago Mr. Hennah discovered the bones of Elephant and Stag in one of the cavities of the chalk towards the higher portion of the Downs, and there also mixed up with fractured flints and stiff ochreous clay. This fact is of value in enabling us to identify the breccia of Brighton and Kemp Town cliffs with much at least of the wide-spread debris which lies at higher levels on the slopes of the South Downs.

At the western end of Brighton, near the shore, the drift differs somewhat both in its matrix and position from what has been described east of Kemp Town. Patches and coverings of angular chalk-flints are also to be seen, but the chalk is nowhere visible, except in excavations, and even the bottom or shingle-bed has only been reached near the sea. In the low tract between Brunswick Terrace and Hove, an unstratified angular-flint-breccia, of from 8 to 10 feet in thickness, being removed, beds of reddish-brown clay, occasionally mottled, and in the lower part blue, resting upon sands, have been cut into to a depth of nearly 30 feet, for the manufacture of bricks. On a first inspection, geologists might doubt whether these were really strata of the age of the Plastic and London clays *in situ*, so completely is the mineral character identical; whilst their eroded upper surface, on which the chief mass of the flint-breccia is placed, would seem to separate the two deposits. But both these signs are fallacious; for in the very heart of these clays and sands I found fragments of *Mytilus edulis* and other sea-shells of existing species with their colours preserved, and among them three or four perfect specimens of *Littorina littoralis*,—a shell whose form and strength enabled it to withstand violence. And although masses of coarse breccia, similar to that which overlies, are not visible beneath, still thin and irregular layers of finely and sharply fractured flints occur here and there in the clays, with small fragments also of chalk. In following these brick-earth clays to Shoreham, they are found to rest (where wells have been sunk) on a coarse flint-rubble*.

It thus follows, that this detrital deposit of Brighton, however diversified in aspect, and whether it be called Combe Rock, Elephant Bed, or Brick Earth, pertains to one and the same group, and is referable to so very modern a geological era, that the sea-shells now living then prevailed, although the great land-animals which also then lived have long ceased to inhabit our country. The presence of the sea-shells in this coast-portion of the drift is, I believe, solely due to the broken materials having been washed down into a nook or depression then occupied by the sea. At higher levels they are never found.

Those of my geological friends who have hitherto considered this coarse breccia to have been formed somewhat in the same manner as a sea-beach, must therefore excuse me when I differ from them in

* Fossil bones of quadrupeds have recently been found low down in this brick-earth of Hove and Shoreham, associated with broken sea-shells of existing species.

expressing my belief, that whilst the water-worn subjacent rounded-pebble-bed (fig. 7, *b*) was really so formed, the overlying detritus was accumulated under entirely different physical conditions. Although very properly applied to the old shingle-bed, the explanation of a "raised beach" fails entirely in regard to the overlying drift and breccia.

In some of those tracts where steep cliffs or even high hills slope rapidly seawards, as on the south coast of Devonshire, there may be no difficulty in admitting Mr. Austen's explanation*, viz. that the rubble due to long diurnal action produced taluses on the sea-shore, the materials of which have covered some of those beaches of whose subsequent elevation geologists have noted so many examples. I must, however, say, that I cannot admit the application of that view to the north-west coast of Devonshire near Barnstaple any more than to the Sussex coast. There Professor Sedgwick and myself described† the very remarkable raised beaches of Baggy Point covered by coarse local drift, and showed how irregularly the ancient shore-deposit has been thrown up northwards until it attains a height of about 90 feet above the sea. Such cases of difference of level within a small area cannot be reconciled with the view which would consider such sea-beaches as any indication of the former level of the sea.

Dwelling no further at present upon the North Devon sea-beaches, I merely refer my readers to the memoir in the 'Geological Transactions,' reproducing on this occasion the opposite woodcut, formerly used, to show the analogy of this North Devonshire case—a coarse drift overlying regular beds—to that of Brighton‡.

In Sussex, at all events, the wide spread of the debris over the low and undulating tracts to the west of Brighton, and its relations to the inferior marine shingle-bed, as well as to the nearest chalk-hills, quite exclude the hypothesis of the diurnal descent of rubble from high ground. There, whether in the form of piles of angular flint, lumps of broken grey-wether-sandstone, or masses of clay or loam with some included angular flints, the varied accumulation lies at very different altitudes. At the west end of Brighton it rises from Hove to the summit-level of the railroad and to the highest windmills, a mile and a half inland. By no imaginable process of the longest continued diurnal action could any portion of this detritus have been gradually derived during ages from the low chalk-hills. There is a total absence of the steep inclined plane which is required in all such cases, and the hypothesis is therefore necessarily excluded. As soon as you throw off the heaps of flints (or of clay and sand with fragments, as the case may be) which cover the chalk, the latter is found to be deeply eroded and channeled, with its fissures irregularly filled up, —the detritus usually very ferruginous; and without the intervention

* See Memoir On the Superficial Accumulations of the Coasts of the English Channel, &c., Quart. Journ. Geol. Soc. vol. vii. p. 118 *et seq.*

† See Description of a Raised Beach in Barnstaple or Bideford Bay, &c., Trans. Geol. Soc. N.S. vol. v. p. 279 *et seq.*

‡ I here give to the subjacent rocks their proper term "Devonian" instead of "Silurian," for which, judging from their external aspect and slaty character, they were mistaken in the year 1835. See Memoir, *supra cit.*

of any such shingle-bed as that which appears at the bottom of the same breccia in a part of the coast-cliff. We find, in short, that this Brighton Breccia is nothing more than a sharply fractured va-

Fig. 8.—*Pictorial Section of the Raised Beach in Barnstaple Bay.*

a. Local Debris or Drift. *b.* Raised Beach. *c.* Hillocks of Blown Sand. *d.* Devonian Rocks.

riety of that general drift of the South of England, which has been produced after the formation of all the Tertiary deposits, properly so called.

In the first cutting of the railroad from Brighton to Worthing, very fine examples of sinuous pipes and erosive cavities are seen; and some which resemble dykes of iron-sand are very conspicuous. It is possibly from this iron-ore that the chalybeate spring of Brighton rises near Furze Hill (Wick); and the same masses supply much of the brick-earth for the construction of the town. Whether some of these masses belong to the older tertiary age, or all to the drift-epoch under consideration, I do not yet feel assured.

Extension of the Angular Drift along the South Downs (*westward*).—For forty miles to the west of Brighton, the surface of the slope of the South Downs is covered with myriads of loose chalk-flints which have been derived from the subjacent rock and especially encumber the north and south depressions. Still further to the south these flints are more fractured and constitute a zone of drifted materials including many angular flints, which increases largely in width as you travel towards Chichester. From the hills, slopes, and great plain of flint-gravel north of Worthing, through the woodlands and arable land of the Duke of Norfolk's property, and from Arundel to the sides of the Slindon Hills, it directly covers the chalk. Highly ferruginous loam and stiff clay (evidently the remains of the Plastic-clay) usually form the cement in which fragments of angular flint are enveloped. In descending from the bare chalk above Slindon, the detritus is seen to have accumulated partially on the slopes to which some stiff clay is still adherent, and then to have been tumultuously aggregated on the plateau of Slindon Common, where the highly eroded surface of the chalk has been exposed by quarrying out the angular gravel; exhibiting much the same appearances as in the railroad-cuttings above the west of Brighton, i. e. with pipes, cavities, and dyke-like vertical bands of drift.

The drift, in fact, here covers a powerfully eroded low plateau of chalk, on which clay, sand, and angular detritus have been irregularly distributed.

From the picturesque undulations at Avisford, which form the south edge of this plateau, for two miles on the high road from Arundel to Chichester, the detritus is exposed on either side of the road, and often in the form of the so-called "Combe Rock" of East Sussex, wholly unstratified, and in thicknesses of 12 to 20 feet, but in which, here and there, as in many other parts of its range, this drift exhibits rude and irregular lamination, and occasionally a sort of oblique lamination. Near Westergate it rests on fine sand, but for the most part is associated with stiff clay, both of them resulting from the breaking up of the Tertiary strata. In the gravel-pits at Aldingbourne, the drift, of a deep ochreous red colour, reposes on a highly disturbed and broken surface of Chalk-with-flints. The upper strata of the Chalk exhibit so much contortion and have been so much thrown about and shattered as if by powerful earthquakes, that the geologist can easily picture to himself how a little more force would have broken up and thrown off the imbedded flints into the mass of drift. As in numerous other places along the range of the South Downs, the surface of the chalk has been sharply broken up and deeply indented; the cavities being filled up with reddish ferruginous drift. Everywhere, in short, we read the same lesson, and learn that, having been subjected to great dislocations, the hardest fragments of the Chalk-formation have been mostly shivered into fragments and piled up in heaps in one place, or poured tumultuously into cavities in another, or interlaminated rudely with sand in a third. The whole tract, ranging westwards by Box Grove Common, Stoney-fields, and the slopes of Goodwood to the flat country north and north-west of Chichester, and thence extending by Stansted Park, Aldsworth Common, and Havant to the foot of Portsdown Hill and to Portsmouth, is covered with similar detrital matter, including stiff clay and sand; but with these are invariably found heaps and masses of angular chalk-flints. Nowhere do rounded shingle or true pebble-beds form part of this rubbish, although I shall presently advert to a sample of such rounded gravel which has had a very different origin and was formed at a much older period.

Those portions, for example, of the clay of Bere Forest, which are also partially *in situ*, indicate, as at Newhaven on the east, the bottom of an old tertiary trough between the chalk of the western extremity of the South Downs on the north, and the chalk-outlier of Portsdown Hill on the south.

The zone of coarse flint-breccia in the south of Sussex has an east and west range coincident with that of the South Downs, and throughout the tract west of Arundel its northern edge is not less than six miles distant from the present sea-shore.

In some spots it rises to a certain altitude on the slope of the South Downs, particularly between Slindon and Goodwood; but its chief masses have been lodged, as at Slindon Common, in the flatter ground nearest to those hills, and have not been transported far from the sources of their origin.

The broad coast-flats of Little Hampton and Bognor have all been more or less overspread with detritus, which, although of very different value to the agriculturist, has had precisely the same origin as the pure angular-flint-breccia of the hill-sides. No line of separation can be drawn between the many flints with reddish clay, and the few flints in copious masses of clay, loam, sand, &c. This plain of rich arable land is chiefly composed of the breaking-up of the Plastic-clays and sands, and of the London-clay, mixed together irregularly. But these materials are interspersed with, and also slightly overspread by, angular chalk-flints. Instead, however, of being dominant, as on the higher slopes of the South Downs, the angular flints are much more sparingly distributed through this clay or loam of the low country. In truth, any one who will examine the deep ditches north of Bognor*, or the little portion of low cliff which is left at the west end of that bathing-place†, will see that the detrital matter is exactly of

* In justice to Lady Murchison, I must state that many years ago she detected in the cuttings of the bluish drift of the flats east of Bognor, and also near Anglesea, Gosport, many fragments of existing sea-shells in inland situations, considerably removed from the present shore-line.

† A careless observer might suppose that round shingle formed some part of the argillaceous drift in this low cliff at Bognor. The pebbles, however, which are partially seen are only external, and have been driven up by the present sea. Within the mass every flint is more or less angular.

the same composition as that of Brunswick Square and Hove at Brighton, previously described. At all the localities along the coast which are flat and far removed from the chalk-hills, the chief mass of the re-aggregated materials* have been derived from the Tertiary formations, the harder parts of the latter now only remaining on the sea-shore, as in the Bognor, Middleton, and Oar rocks; or still form partial cliffs as at Bracklesham. Wherever you examine this detritus, whether it be on the external slope or talus of the chalk-hills, or in the broad, slightly inclined flats extending to the sea, you find that, whatever may have been the materials acted upon, they have all been violently broken up, and gathered tumultuously and without a symptom of having been subjected to ordinary tidal coast-action to produce stratification, or long-continued aqueous abrasion to round the flints; nor do they anywhere contain marine remains, except where the detritus has been shed off into the low situation, at Hove, and has there encroached upon the sea-level. All this drift I consider to have been shed off from north to south, and to have been formed coincidently with the flint-drift described as lying between the escarpment of the South Downs and the central dome of the Wealden.

Round Tertiary Shingle on the South Downs.—The only decided exception to the complete denudation of the tertiary rocks throughout the slopes of the South Downs, with which I am acquainted, in addition to the well-known example at Newhaven, is a local accumulation of rounded gravel (within the range of the chalk *in situ*) to which my attention was directed by Sir H. Goring and Lord Edward Howard. The chief mass is at Clapham Common, half a mile east of Patching, and in the angle between the old Arundel and Brighton road and that which traverses to Horsham. There it has been long quarried for gravel, and is associated with much tenacious mottled clay, extensively used as brick-earth. On examination, it is evident that this clay and gravel deposit, lying as it does about three miles inland, at about 150 or 200 feet above the sea, and spread over a broad talus in a depression of the chalk-hills, could not be considered in the light of a raised beach, like that at Brighton, but must belong to an early tertiary epoch; in other words, to the pebble-beds of the Plastic-clay (or Woolwich Beds). One or two layers of these rounded pebbles mark a slightly undulating stratification in the clay; but their overlying portions have been since re-aggregated in heaps which cover the clay. Not a single angular fragment of chalk or flint is mixed up with these pebbles or with the clay, except those which may have fallen from the thin coating of angular drift which overlies them. The deposit, in short, is such as it was originally aggregated on the ancient surface of the chalk when the tertiary beds were formed by sea and tidal action. Although in my visit I detected no fossils in it, I have no doubt, from the nature of the clay and sand and the form of the pebbles (exclusively rounded chalk-flints), that it is truly a portion of the Plastic-clay formation *in situ*, which has resisted denudation†.

* The Drift at Bracklesham contains Elephant-molars.

† Striking examples of this resistance to denudation are seen in the cappings of the hills of chalk in Salisbury Plain; as at Sidbury Hill, Chiltern Clumps, Quarley Mount, Thorney Down, and Clairbury, all of which consist of plastic-clay and highly rounded pebbles of chalk-flints.—[October 1851.]

Lying in a gently sloping common from which the chalk-hills rise up to the north, these pebble-beds are completely shut out from the sea-coast by the advanced chalk-hill called the "Miller's Tomb," which, acting as a buttress, has, I conceive, checked the outscouring or denudation which has swept away and re-aggregated the greater portion of the tertiaries along this tract, and has so powerfully eroded the surface of the chalk and shattered its flints. The raised sea-beach at Brighton, which is proved to be very modern by the remains of existing sea-shells and cetacean bones, as well as by some portions of terrestrial quadrupeds, which were found in it, together with foreign pebbles, differs very greatly in composition and contents from this old tertiary deposit; although the well-rounded flints of each are scarcely to be distinguished, and both, resting on eroded chalk, are covered by the angular drift. The tertiary clay of Patching, which is an extension of the deposit of Clapham Common, supports the large pond of Patching; no other such extensive piece of water being met with upon the surface of the chalk.

Detritus of the Hampshire Chalk Range and of the North Downs, as distributed towards the Weald and over the Tertiary Deposits.—The chalk-escarpments which unite the South Downs with the North Downs are for the most part clean denuded along their base (Froxfield and Selborne Hangers). Like the South Downs, however, from which they branch off, they are subtended by coatings and irregular patches of flints which cover the eroded surface of the hills of Lower Greensand which lie nearest to them. Thus, whilst the terraces of Upper Greensand and valleys of Gault are for the most part denuded, the sandy tracts near Liss and Greatham and the white sands of Woolmer Forest, like those of West Heath and Trotton Common, have arrested considerable heaps of them. Here again the debris is purely chalk-flint, probably derived from the same great angle of the fractured and denuded chalk west of Petersfield before alluded to. The debris may here have been translated from South to North, in the depression between the Selborne Hangers and the highest parts of Woolmer Forest. No fragment of these flints has been translated to the sides of the higher grounds further removed from the Hampshire or north and south escarpment of chalk. When the great Wealden denudation is viewed near its western end, as the observer moves along the high-road from Portsmouth to London, the grounds occupied by the Lower Greensand, already described at Rake Common (see above, p. 357), are seen to rise considerably. That formation, as indicated by Dr. Fitton and myself, attains in fact a greater elevation in Hind Head (872 feet) than in any part of its range, except in the eastern prolongation of the same ridge to Leith Hill, which is 960 feet above the sea. Whether the summits of these hills, or the deep combes within them, be examined (and of these the Devil's Punch-Bowl is the most notable example), they are found to be free from all loose transported materials, and denuded down to the surface of the rock, which is only partially covered by a very scanty soil and a meagre vegetation of heath. No sooner, however, do we move north-westwards towards the escarpment of the Hog's Back and approach the depression in the Chalk-hills near Farnham, than much debris is found occupying mounds on either side of the river Wey.

At this north-western angle of the great denudation—i. e. in the tract lying between the forest of Alice Holt on the south-west, and Farnham and the Hog's Back on the north-east, immense quantities of angular and highly shivered chalk-flints are spread out; not only over the hillocks of Lower Greensand on the right bank of the Wey near Wracklesham, but are distributed over the Gault of the broad and elevated plateau of Alice Holt, where I long ago noticed them*.

Copious accumulations of these are also exposed on the road descending from Wracklesham to the Wey, and still better in the new railroad cuttings from Farnham to Alton. The flints are tumultuously piled together and sharply fractured, and, mixed up with pieces of chert and clinkers of the Lower Greensand, are lodged on the irregularly eroded surface of that formation. Thence they extend along the hillocks and slopes on each bank of the Wey eastwards for the space of three or four miles. I cannot, in any way, separate the flint-drift of Alice Holt plateau and Wracklesham from that of the hillocks on the sides of the Wey, in which the remains of fossil mammalia have been found; for there is a perfect continuity between all these detrital accumulations. Nor can I dissociate from the same drift, the heaps of flint-debris and gravel which are spread out northwards from Farnham over the surface of the clays and sands of the western portion of the London Tertiary basin. For, as the debris which has been translated to the surface of the older rocks on the escarpment side of the chalk is purely local, so that which has passed to the north has local distinctions only. Thus, to the north of Farnham and the Hog's Back, we find not merely the broken chalk-flints in the drift, as derived from the adjacent ridges, but also highly rounded flints, all of which, like those of Patching on the South Downs (p. 372), have been denuded from the pebble-beds of the lower tertiary clays and sands, and are associated with some fragments of the grey-wether grit. Both the latter have been abstracted from the subjacent and denuded formations *in situ*. In proportion, indeed, as you recede northwards from the chalk of the Hog's Back and North Downs, and descend over the tertiary clays and sands ranging by Frimley to Bagshot Heath and the hills north and west of Windsor, the angular chalk-flints are seen to become scarcer and the rounded pebbles more abundant, the latter being derived from the extensive dismemberment which the tertiary beds have undergone as well as the subjacent and flanking chalk-ridges. Wherever hills of the London Clay have arrested these drift-accumulations, as around Binfield†, they are as tumultuous and unstratified as any described on the external slope of the South Downs, and they lie at all sorts of altitudes, from the banks of the Thames to the heights around Farnham.

* Trans. Geol. Soc. Lond. N.S. vol. ii. p. 100.

† In many parts of this gravel, where the oxide of iron prevails, the materials have been so cemented as to form a very hard rock. This "rubble," which is the equivalent of the 'Combe Rock' of Sussex (*antea*), occurs also around London.

But to return to the escarpment of the North Downs. In looking at the fracture, dismemberment, and great denudation of the chalk and tertiary strata near Farnham, we have before us a very adequate cause to explain the abundant local distribution of such detritus. In short, the angle which the North Downs here makes with the Hampshire or Selborne escarpments has probably been the scene of still greater rupture than that to which allusion has been made to the west of Petersfield, where the latter range is confluent with the chalk of the South Downs.

In looking to the present drainage of the county, and in perceiving that the western tributaries of the Wey flow along the south side of the Hog's Back, or parallel to the axis of the chalk-ridge on the one hand and to the Wealden on the other, we have before us somewhat of the same geographical feature as that before described, on the other side of the great Wealden axis, where the river Rother flows from a depression in the chalk west of Petersfield.

For some miles between Farnham and the environs of Godalming, I am not aware of the existence of any drift; but the Lower Greensand, particularly that portion of it which is charged with ironstone-bands or "clinkers," has been powerfully denuded, and is always near the surface. In proceeding farther eastwards along the longitudinal depression, leaving the hills of chalk on the north or left hand, *i. e.* to Compton and Godalming, we reach the depression called Pease Marsh, where, owing to a former excavation, to which I do not now refer, the whole of the greensand which surrounds it was removed, and the Weald Clay first denuded and afterwards covered by copious accumulations of gravel and clay. That the Weald Clay constituted, at the period of the spread of the debris under consideration, a true terrestrial surface*, was first suggested by Mr. Austen, who has detected thereon, and beneath all the detritus, stumps and stems of forest-trees, the former vertical, and as if in a growing position.

As the detritus of Pease Marsh occasionally presents somewhat of stratified appearances, more indicative of regular deposition under water than the drifted materials, to which allusion has already been made; and as Mr. Austen, who recently pointed out to me the leading features of the deposit†, entertains opinions respecting the origin of this detritus differing from my own, I beg permission to enter into a little detail, the more so as a communication formerly made by my friend to the Geological Society, and relating to this very point, has never been communicated to the public.

The patch of detritus in question is not merely confined to the

* Vide *supra*, p. 288. In consequence of this Memoir taking its place at the end of the present volume (its publication having been unavoidably deferred), and Mr. Austen's Memoir, On the Valley of the Wey, as well as the Papers on the Folkestone Bone Bed and the Sangatte Cliff, by Mr. Mackie and Mr. Prestwich respectively (in each of which Memoirs detailed accounts are given of phænomena alluded to in the present Communication), having already appeared in the Quarterly Journal of the Society, references are here made to the above-mentioned Papers whenever required.

† See the Memoir alluded to in the preceding note; read June 25, 1851. *Vide supra*, p. 278 *et seq.*

lowest part properly called Pease Marsh, but ranges from Compton and Godalming on the west, by Chilworth to Weston-street and Albury on the east, a distance of about six miles. Its width, depending on the form of the ground and the surrounding hills, contracts from a breadth of about two miles from north to south, near Godalming, as pointed out to me on the spot by Mr. Austen, to a very narrow band in the longitudinal valley of the Tillingbourne brook near Albury; whilst in the transverse depression, extending southwards from Guildford into the Weald (the line of the Surrey and Sussex Canal), it has a breadth of nearly four miles.

In the lowest portions at Pease Marsh, where this drift is cut through by the branch-railroads to Godalming and Reigate, it is covered by much clay and loam; but neither in the one mass nor in the other could I discover better proofs of stratification than are occasionally to be seen in the gravel-deposits of Hyde Park and Kensington. The chalk-flints are of all sizes and colours, some angular and others somewhat abraded; and with them are associated numerous flattened fragments of the "clinkers" of the Lower Greensand, and rarely a piece of the grey-wether-sandstone of Tertiary age. None of these materials have been fashioned into true shingle, and none of them can, I think, have been accumulated in a bay of a former sea; for, although some marine accumulations may have such irregular appearances, the materials could scarcely have been collected in a fiord or bay without having some fragment of a marine shell among them. At a few spots, just as around and under London, some sandy portions of the mass are dovetailed in oblique laminæ in lines of false-bedding among the flints, which as a whole naturally lie in more or less horizontal masses, and in conformity to the shape of the ground on which they rest. The remains of extinct Elephants, Stags, and other lost species of mammals, which have long been known to prevail here, were found usually (at least, according to Mr. Austen, all the most perfect remains) in the lower part of the stony detritus, or beneath it and incumbent on the subjacent Weald-clay, to which, as before mentioned, trees are still adherent.

In its southern extension, or towards the Wealden, this drift continues to be covered with the same mass of unstratified clay along Poundstone brook, and rises gradually to the village of Wonersh, to which point chalk-flints accompany it. But when followed still further southward, the drift changes its character, and instead of chalk-flints we find in it (at a still higher level in the low hills south of the Wonersh turnpike-gate) exclusively the hard debris of the Lower Greensand; the surface of that rock having been eroded, and its cavities filled with the detritus of its own harder parts.

In pursuing this drift eastwards from Pease Marsh by Chilworth to Albury, it contains chalk-flints all the way, and is seen in like manner to rise to some height above the present watercourse, constituting sloping mounds of about half a mile in width, in some of which localities, and particularly near Weston-street, the mixed flint-detritus, where coagulated, is scarcely to be distinguished from the "Combe Rock" of Sussex.

In ascending a tributary of the Tillingbourne to the south of Albury Heath *, I perceived, that whilst the summits and slopes of the hills of Lower Greensand were there entirely denuded, the little upland valley (as exposed by deep drains) is filled, from side to side, with coarse debris of the harder beds of the surrounding formation (chert, clinkers, &c.), but void of chalk-flints.

In looking to these facts, and to the distribution of the rock-masses and the form of the country, we may, I think, apply nearly the same reasoning as to the environs of Petersfield and Pulborough. That the mass of the drift accumulated in Pease Marsh and the valley of the Tillingbourne proceeded from the nearest great fractures in the chalk and greensand admits, I think, of little doubt. Thus, the clinkers that constitute one half of the detrital matter have been washed in from the surrounding hills of Lower Greensand. The mass of the flints may, indeed, have been well derived from the narrow impending broken chalk-ridge, and the fissure by which the Wey escapes. For here, as in parts of the South Downs, there is evidence of anticlinal elevation as well as transverse fracture, to which Mr. Austen called my attention, and by which, in one spot near St. Martha's Chapel †, the Gault is thrown up in a mural form, together with the Chalk. The few fragments of grey-wether or tertiary sandstone which occur in the drift are, I have no doubt, remnants of a former capping of the adjacent chalk-ridge at Guildford.

Again, when we move southwards into any adjacent depression, we find that the only debris is that of the greensandstone of the adjacent and surrounding formations. Thus, I repeat, that we here have pretty much the same results of longitudinal and transverse fractures of the adjacent rocks along a west and east zone, as we have in the south-western extremity of the region or other side of the great axis.

Under such circumstances, and particularly when I see this drift at Albury and on the sides of the Tillingbourne, and again to the south of Wonersh, mounting to heights of 60 and 70 feet above its level in Pease Marsh, I can neither admit that it could have been accumulated in a lake, nor, in looking to the exclusively terrestrial remains which are found in the deposit, can I believe that this was an estuary of a former sea. Anyone who examines the highly eroded surface of the chalk, and the fractured tertiary detritus above Merrow, and, passing over the summit, descends into the beautiful valley of the Tillingbourne, whether near Chilworth or at Weston-street, but particularly at the latter, will see what quantities of shattered chalk-flints are even now lying dislodged from their natural position, and overlapping successively the escarpment-edges of the Lower Chalk and Upper Greensand. A very little more transport down the steep, in an ancient condition of things, and when the depressions were occupied by broad bodies of water upwards of 200 feet above the present drainage, and they would be aggregated in the depressions like the "Combe-rock" at Weston-street. I am disposed, indeed, to think that a low imperfect anti-

* In company with Mr. H. Drummond, M.P., of Albury Park.

† The Lower Greensand at St. Martha's Chapel is 580 feet above the sea.

clinal, to which Mr. Austen directed my attention, and which runs along the Greensand from Chilworth to Weston-street, may further explain the shedding-off of some of the coarse detritus of that formation, and serve to account for the unusual quantity of rubbish in the lower part of the depression at Pease Marsh*. The heavy mass of unstratified clay by which the whole is covered, brings it distinctly into the same category as the bone-preserving loam-drift of other places.

In this, as in all the other tracts hitherto described, I see little chance of being able to separate the drift, which is more or less loose on the sides of the hills, from that which has been cemented and aggregated in combes and hollows, and in the lower parts of which the fossil animals have for the most part been entombed. Such remains have, indeed, been occasionally found considerably above the lower tracts. One example has already been cited on the Downs of Brighton, and another was mentioned to me by Mr. Austen, who was in company with Dr. Buckland when the latter discovered the bone of a Rhinoceros in loam on the side of the Greensand escarpment, and at some height above the massive slopes of drift on the banks of the Tillingbourne. I believe, then, that the detritus in and around Pease Marsh was chiefly the result of disturbances of the adjacent strata, whilst broad and torrential bodies of water were moved along under the escarpment of the North Downs, and translated the debris into natural depressions. Admitting that the detrital gravel offers clear signs of having been accumulated under water, I cannot, in the occasional transverse lamination of the sand, see any proof that the accumulations were not made to a great extent in the same manner as the Brighton breccia. If these false laminæ or oblique striæ were formed by the sea, they must be assumed to afford also proofs of a shore-deposit. At all events, such false stratification is usually seen where the associated sand and pebbles indicate long-continued abrasion and rolling, which is certainly not the case in the deposit under consideration.

In this case, a drifting-action, which swept the debris of the adjacent hills into the hollow of Pease Marsh, might leave them to settle down during a pretty long time, there being no egress for the waters except by the narrow gorge of Guildford. It may also be well imagined how, in this ponding-back of the waters, the coarser and heavier materials would be collocated, just as we now find them, and how the stiff loam, resulting from the final settlement of the smaller particles of matter in the turbid water, would naturally form the covering of the stony debris. It is this thick, impervious, superficial clay which has protected the bones of the large animals from atmospheric action and decay; whilst the abundance of bones in such hollows can be only, I imagine, satisfactorily explained by supposing that the animals were drifted into these depressions and entombed beneath the mass of detritus.

* Mr. Austen further spoke to me of evidence he had to prove, that longitudinal fractures have occurred along this valley since the deposit of the drift and gravel.

Before I quit the consideration of the Guildford district, I may say a few more words on the outward slopes of the North Downs*. It does not, however, appear to me that, with the exception of the portion of the North Downs where the chalk is reduced to a narrow and inclined ridge, viz. the Hog's Back and the tracts east and west of Guildford, there has been almost the same amount of shattering of the flints which is observable on the slopes of the South Downs, between Beachy Head and Portsdown Hill. On Guildford Race-course, and particularly above the villages of Merrow and Clandon, the surface of the chalk has indeed been powerfully affected, and millions of loose and half-fractured flints form masses which have been in great measure purged of their original chalky matrix, and are lying in a loosely-aggregated state, as if ready to be translated into combes and depressions. Nearer the escarpment the erosion has been still more violent, and deep pits and holes in the chalk are filled up with broken flints and the rubbish, resulting from the abrasion of the tertiary and overlying strata, all tumultuously piled together. Nevertheless, few of these flints present the same sharply-fractured features which characterize those of the Brighton breccia, and for the most part they consist of partially-fractured lumps, the original concretionary form of which is still visible. Again, in descending upon the fine long talus which slopes down from the villages of Merrow and Clandon to the lower country of Send, Ripley, and Woking, the Tertiary clays and sands do not exhibit on their surface anything like that amount of flint-drift which characterizes the southern slope of the South Downs, the angular flints being very small and sparingly distributed, except at a few localities, where they are sufficiently abundant to be sifted out of the sand and used as gravel.

In following the line of the railroad from Albury to Dorking, I observed angular chalk-flints on the surface of the whitish sands of the Lower Greensand. Near the summit-level of the railroad near Gomshall, they lie in detached patches, though not in the same volume as on the sand-hills of the same age near Petersfield. Now, as no streams have ever descended over these hills of sandstone, since the present configuration of the land and desiccation of the country were effected, I equally refer them to the same agency of drift as that which swept greater volumes of them into the adjacent hollows.

In some places where the sand passes into a state of sandstone or rock, its surface is seen to have been eroded and its cavities filled in with the flint-debris, just in the same manner as that by which the Chalk has been affected; and of this Dr. Fitton has cited a good example west of Dorking in this very tract†. No sooner, however, do

* I do not profess to have much examined the surfaces of the broad masses of chalk which extend from the North Downs over Kent; but it is well known that a great portion of their surface exhibits superficial detritus similar to that which I have noticed, as has indeed been well described by Mr. Trimmer (see Quart. Journ. Geol. Soc. *supra*, p. 34 *et seq.*). Besides the well-known fossil localities in the environs of London, the remains of Mammoth, *Bos Urus*, &c., have been found in drift by Mr. Bland at Hartlip near Rainham in Kent, a fact I became acquainted with through Dr. Plomley of Maidstone.

† Trans. Geol. Soc. Lond. N. S. vol. iv. p. 144.

we proceed eastwards under the chalk-escarpment and reach another marked depression, or that around Dorking, which like that of Pease Marsh is contiguous to a great transverse fissure in the chalk, than we again meet with detrital accumulations and the remains of fossil quadrupeds, the bones of which were also found chiefly at the bottom of the gravel.

The Dorking Valley and the hollows around Deep Dene have been for the most part swept clean of all stony debris and only fertilized by loam; but the low hills on the banks of the river Mole near Brockham Green and Betchworth are partially covered with thick patches of flint-drift, and it was in these localities that the fossil quadrupeds* (Mammoth, &c.) were found, under a considerable mass of loamy clay†.

Other examples of accumulations of this nature have been long ago described at Petteridge Common on the Weald-clay three miles south-east of Reigate, and at Nutfield Marsh. On the north side of Tilburstow Hill and at a very considerable height above the valley of Godstone, the beds of chert of the Lower Greensand which are there broken up for gravel, are covered by unstratified clay. In it are a few minute fragments of chert, chalk, and flint, and I refer the whole to the period of drift under consideration.

Hitherto the drift under the scarp of the North Downs (as we proceed from west to east) has been chiefly spoken of, as either occurring upon the Lower Greensand with its Neocomian (Atherfield) clay or overlying formations, or upon patches of the Weald-clay which have been denuded at no great distance from the Chalk-hills. From the longitudinal meridian of Leith Hill, however, the drift begins to overlap the Weald-clay zone; a fact precisely in accordance with what I have noted on the southern side of the central dome. The facts seem to indicate, in short, that on either side of the central dome bodies of water have (as the Chalk and Greensand recede to the south and north) necessarily overspread those portions of the Lower Greensand and Weald-clay of Kent, which lay exposed in the line of their transport. Thus the Weald-clay is covered at intervals either with drift-loam or with debris of ironstone or chert of the Lower Greensand; and just as a large portion of the same clay on the south side of the axis has been fertilized by this operation, so has the soil been improved which occupies the tract extending from the south of Bletchingley and Godstone to Eden Bridge.

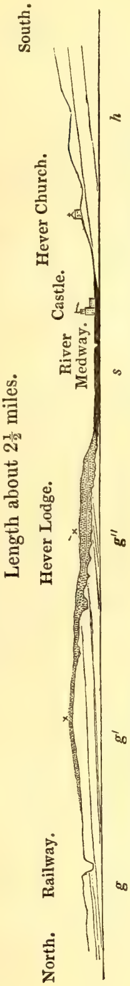
The most singular by far of all these collocations of drift in this tract, is one which occurs on some dome-shaped hills of the Weald-clay near its junction with the Hastings sands to the north of Hever Castle, celebrated as the residence of Queen Anna Boleyn. There, in two farms belonging to Mr. Waldo, the highest grounds, or those

* See Mr. Morris's Note of the occurrence of these fossil bones, Loudon's Mag. Nat. Hist. vol. ix. p. 46.

† Immediately to the east of the station at Betchworth I observed that the chalk-marl, which is there cut through, has been thrown into an undulation, much denuded, and covered by a capping of loamy argillaceous drift with a very few fragments of flint.

towards the north and west, are covered with loam and brick-earth, occasionally fertile enough to constitute hop-grounds; whilst the surface is sprinkled with large broken chalk-flints (see fig. 9). In passing to the south-eastern slopes which flank the valley of the Medway, this loam with flints passes into a gravel, the flints become smaller, and for the space of a mile and a half are spread out in what the country-people call the "plains," which are, in fact, plateaux 60 or 80 feet above the adjacent valley of the Medway. This drift has been largely excavated at Hever Lodge Farm*, where it consists of small flints of yellow, red, and white colours, the greater number angular, and fragments of clinkers and chert of the Greensand, with some rounded black pebbles of flint, similar to those which have been derived from the older tertiary strata and have been before alluded to. These are mixed up in foxy-coloured sand and loam, and where iron has predominated the fragments are occasionally cemented into the concrete here, as in the west of Sussex, called "rag-stone." These accumulations attain more and more of a stratified and water-worn character as they pass from the summit of the dome or plateau to the valley of the Medway. On the higher grounds the loam is entirely unbedded and the flints are large and angular; further on they diminish in size and are associated in the above-mentioned gravel; and still farther on, in the flats west of Tunbridge, the accumulation is one of still finer gravel, which has a rude stratification.

Fig. 9.—Diagram, showing the position of the deposits of Angular Drift lying on the Weald Clay at Hever Lodge Farm.*



s. Silt and modern alluvium. *g*. Weald-clay, not covered by drift.
g′. Weald-clay covered by some loam and a few large broken flints, *x*.
g″. Weald-clay covered by the gravel-drift described, ′*x*. *h*. Hastings Sand free from Drift.

* This is one of the cases of capping of the Weald Clay in this district, as alluded to by the author, which he only recently examined in detail.—[October 1851.]

The drift of Hever Lodge occupies a remarkable position in being about nine miles distant from the nearest chalk-escarpment of the North Downs whence the flints in it could have been derived. I may also mention, that the spot is nearly to the south of the N. and S. fracture in the chalk in which the Darent flows. It is, however, separated from the North Downs in that parallel by the lofty hills of

* Fields were here cut into to the depth of 14 feet and over a surface of 12 or 14 acres for the extraction of ballast for the South-Eastern Railroad.

Lower Greensand on which Seven Oaks is situated, on which much drift has been arrested, and through which there is no transverse opening.

Looking therefore to the present configuration of the land, it is impossible that any great ancient river following the direction of the present streams could have transported these materials. Whether, then, they came from the fracture of the Darent, or were translated from the greater rupture and depression in the chalk north of Maidstone, in both cases they must, unlike the Petersfield drift (p. 356), have been carried in a direction completely opposed to the present drainage of the lands. They must, in short, have either been translated over intervening hills or up the present valley of the Medway.

The loam-drift with flints extends indeed all down the banks of the Medway to Maidstone*, and, occasionally spread over flats, is exposed

* Since this memoir was read. I made an excursion to Maidstone, to ascertain if the distribution of the drift in that neighbourhood were similar to that cited from other localities along the escarpments of the South and North Downs. This examination completely confirmed my views, in showing the extensive diffusion of the detritus of the Chalk, over the hills of Greensand and Kentish Rag, and thence extending to the Weald-clay. It is manifest that the whole of the rocks of the tract, where the Medway escapes through a grand transverse fissure and denudation in the Chalk, have been most powerfully broken up and dislocated. Not only is the surface of the Upper Chalk deeply eroded, and filled with red drift (there 600 feet above the sea), but huge, loose masses of the grey-wether tertiary beds have been hurled down the escarpments and lodged on the surface of the Lower Chalk, where the largest of them have been raised by the early Britons into "Cromlechs." Some loose flints are spread over the Lower Chalk; but the valley of Gault is clean-denuded. On the other hand, the northern side of Pennenden Heath and the Chalk-escarpment have arrested considerable quantities of flint-gravel, which increase in thickness as you approach the summit, about 200? feet above the sea. Fossil bones of Mammoth, Rhinoceros, Hippopotamus, Stag, Horse, &c., have been found, as I was informed by Mr. Bensted, in the excavation of brick-earth and flint-drift on the slopes above the Jail at Maidstone, which I had examined, and not less than 80 feet above the river. Dr. Plomley indeed gave me specimens of the teeth of *Rhinoceros tichorhinus* which had been found there. Freshwater and Land Shells also occurred in some of the overlying loam, and the whole case is therefore precisely in accordance with that of other places cited. No one can separate this drift of the summits of Pennenden and Barming Heaths from the bone-drift of Maidstone.

There are few districts in the South-East of England which better merit a detailed, monographic description than that around Maidstone, where the extraordinary curvatures and fractures of the Kentish Rag (each anticlinal line being more or less parallel to the bends of the Medway) and the tumultuous infillings of drift in the cavities of the numerous quarries offer the most striking confirmation of my views. Mr. Bensted, whose discoveries are well-known to geologists, was so obliging as to point out to me, a rapid anticlinal of the grit near Aylesford, where the overlying flint-drift seemed to be conformable to the strata which dip off at an angle of 55°; whence it might be inferred that the movement which produced this flexure was even posterior to the deposition of the flint-debris. If it be certain that the drift has been tilted by an upheaval of the rock beneath, then this is a case analogous to that observed by Mr. Austen near Guildford. In the Aylesford case, however, I have still some doubt on the point; as in an adjacent quarry to the north, where the Kentish Rag has undergone another contortion, the inclined strata of grit are in contact with gravel, which has a sort of rude horizontal bedding. However this may be, one feature at the same locality is too remarkable to be passed over in silence. The surface of the upheaved grit (there very cherty) has been bored into by *Pholades*, and if these shells should prove to be of existing near Yalding Station, capping a small elevation of Lower Greensand (Neocomian).

The arrangement of the drifted materials also shows, that the waters, whatever they were which translated them, acted in an opposite direction to the present Medway; for in proportion as you approach to Maidstone and the North Downs, the fragments of flint become larger and much more abundant.

In cutting the line of the Dover Railroad from Tunbridge to Folkestone, various other heaps of drift were removed from the surface of low domes of the Weald-clay on which they had been arrested, as at Marden, Headcorn, Pluckley, &c. At Marden, and at about a quarter of a mile east of the station, the excavations made in the summit of a low dome are still to be seen, whence much brick-earth or loamy clay, with a thick mass of shingly gravel, chiefly the detritus of the Lower Greensand hills, were abstracted from the surface of the Weald-clay for the construction of the railroad. The teeth and defences of a Mammoth were found here under about 15 feet of this detritus *. The position of these remains at a height of about 70 feet above the river Beult or its tributaries, renders it impossible to suppose that they were accumulated under the silt and gravel of any stream which did not extend over all the lower country between the hills of Lower Greensand on the north and those of the Hastings sands on the south. Here also, as at Pease Marsh, the remains were found

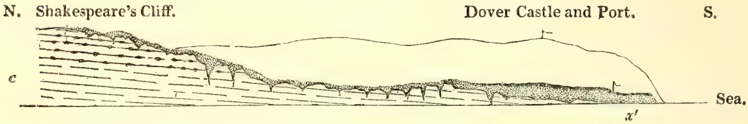
species, we might then suppose, that at the period when the sea formed the Brighton pebble-beds, it entered up an estuary as far as Aylesford; which at this day is very little above the influence of high spring-tides. This subject calls for elucidation. The *Pholades* may, however, have belonged to an early tertiary or older period, and thus prove alien to the present subject, an opinion to which I incline, because the beds affected by them are separated from the flint-drift by a band of mud-like loamy silt, in which many fragments of shells of the Lower Greensand occur. I willingly leave this subject in the hands of Mr. Prestwich, to whom Mr. Bensted has also indicated the above-mentioned curious phænomenon, and who has been occupying himself for some time in the study of the superficial detritus of Kent. When the remains of *Hyæna* were found many years ago in fissures of the Maidstone Grit by Mr. Braddich, at Boughton Malherbe, six miles S.E. of Maidstone, I visited the locality in company with Dr. Buckland and other geological friends. Whether the cavities in which the bones occurred were really at any time inhabited caves, as our able and zealous leader wished to prove, or were simply a portion of the drift so often alluded to, I have a distinct recollection that the bones had been preserved under a copious accumulation of impervious loam and clay, which had spread over the orifices and plugged them up, at considerable altitudes. Mr. Bensted has since informed me that in some of the cavities of his quarries, 150 feet above the Medway, fossil bones have also been found under great masses of similar drift. The chief localities where fossil Mammalia occur in this part of Kent have, indeed, been clearly described by Mr. Morris (Loudon's Mag. Nat. Hist. vol. ix. p. 593, 1836); and this good naturalist informs us that the species of shells (*Helix hispida*, *Pupa marginata*, and *Succinea oblonga*), found usually in the upper (loamy) portion of the detritus, belong to land Testacea, and to such as "inhabit the banks of rivers and marshy places, no decidedly freshwater shell having yet been detected;" whilst the large fossil bones lie in the lower mass and under the clay.—[Added when the Memoir was in type, October 1851.]

* Although the author previously knew of gravel overlying the Weald-clay at Marden (South-Eastern Railway), he only heard of the fossil bones found there since the Memoir went to press.—R. I. M.

near the very surface of the Weald-clay, and had been protected from atmospheric action by a copious cover of clay or loam. At Pluckley, the drift used as ballast for the railways covered beds filled with *Paludina* and *Cyclas* (the Bethersden marble of Kent); and at Ashford, the drift-clay, which is tenacious, reddish, and speckled throughout with angular chalk-flints, at once covers the Weald-clay *in situ,* with its *Cypris Valdensis.* It is also worthy of remark, that here, as in the parallel of the Medway, in proportion as we recede from the main zone of drift, in proceeding from the north towards Rye and Winchelsea, the flints diminish in size, until gradually all traces of them are lost; the southernmost portion of the Weald-clay, as in the flat grounds towards Romney Marsh, being covered by rich loam only.

Drift at Dover and Folkestone.—At Dover (see Section fig. 10)

Fig. 10.—*Diagram, showing the relations of the Angular Drift and Elephant Rubble to the Chalk at Dover.*



c. Chalk (upper part with flints), capped by flint-drift, *x*. *x*. Flint-drift.
x'. Flint-drift, capped with clay and passing downwards into Elephant Rubble.

the terminus of the railroad has been excavated in a considerable thickness of large fragments of chalk, constituting a chalk-rubble, and exactly resembling the lower portion of one part of the Brighton breccia east of Kemp Town, in being composed of broken chalk almost *in situ.* As at Brighton, it fills up a hollow in the solid chalk which opens to the port, and ranging along the shore between the fort and the terminus, has a maximum thickness of 50 to 60 feet. In following this rubble from the station towards the first tunnel, it is seen to thin out and to be supplanted in its lower part by the solid chalk, which rises from beneath it. In its upper portion, however, the breccia passes into a band of the flint-drift, with which it is thus merged. In mounting the hill from the north end of the tunnel, the observer can clearly see how these materials, viz. the white chalk-rubble and the ochreous flint-detritus, form portions of the same deposit, and on ascending to the summit of Shakespeare's Cliff, he will further perceive that the broken-flint-drift which is here mixed up with reddish, tenacious clay, as in many parts of the South Downs, accommodates itself to all the sinuosities of the outline of the chalk. Thence southwards to Folkestone, the chalk-hills are capped, and their indentations filled, with the same detritus, whether it be the Chalk with flints on the summit of Shakespeare's Cliff, or the Middle and Lower Chalk; as is represented in Dr. Fitton's Section of the Chalk of Devon *.

Teeth of Elephants have been found on the shore under the Dover

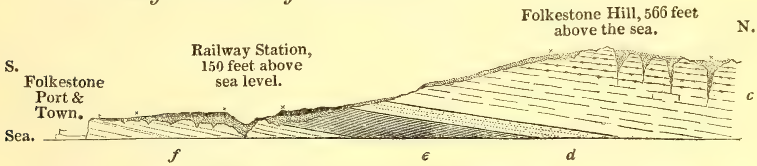
* See Trans. Geol. Soc. Lond. N. S. vol. iv. Pl. X. *b*. f. 9.

cliffs, which from their white colour are supposed to have fallen out of the chalky or lower portion of the detritus.

It is only, however, where the drift fills the depression in which Folkestone stands, that, just as in many other fossil localities, its upper part consists of a thick mass of unstratified clay and loam. Under like physical conditions, like results have followed; and very numerous remains of fossil quadrupeds have rewarded the diligent research of Mr. S. J. Mackie, of that place. They consist of bones of Elephant, Hippopotamus, Ox, Horse, Stag, and Hyæna, a fine collection of which, thanks to the zeal of that gentleman, is now laid before the Society, and of which, at my request, he has prepared an account*. Not anticipating the details of Mr. Mackie, I must, however, after having inspected the chief localities in his company, state the impression that their examination produced on me, and show how they corroborate the inferences drawn from other localities.

The detritus which caps the cliff of Lower Green Sandstone behind the Victoria Hotel (fig. 11), and about 80 feet above the sea, consists

Fig. 11.—*Diagram, showing the relations of the Angular Drift and its accompanying Argillaceous Loam to the Chalk, Greensand, &c., in the neighbourhood of Folkestone.*



c. Chalk covered with flint-drift, *x*. d. Malm-rock or Upper Greensand.
e. Gault, f. Lower Greensand, } covered with the Mammaliferous flint-drift and its overlying clay, *x*.

in its southern part of a mass of reddish-brown clay, which in its course northward expands and becomes in its lower part a white loam, beneath which ochreous flint-gravel, commencing as a mere point or wedge, thickens and thins out according to the inequalities of the surface of the sandstone on which it has been lodged. Now, it is in this lower flinty debris, and at a height varying from 80 to about 110 feet above the sea, that Mr. Mackie has found the greater part of the large animal remains. Here also, as in other places noted, they have been evidently protected from decomposition by the thick cover of argillaceous matter. The researches of Mr. Mackie and Mr. Morris have further detected, in the upper and finer portion of the rubble, but under the clay and brick-earth, two species of *Helix* which are identical with forms now living. If taken by itself, this fact might seem to indicate, that the fossil bones of Folkestone had been simply accumulated in a sort of lake which formerly occupied this depression; but a reference to the data afforded by the surrounding tract prevents the adoption of that hypothesis. The brick-earth, some of which lies at low levels in the ravine north of Folkestone, rises over the surfaces of the Gault, as well as of the

* See Mr. Mackie's Paper, *supra*, p. 257 *et seq.*

Lower Greensand, and is seen at the height of the railroad station, about 150 feet above the sea, and from whence you look down upon Folkestone. It there contains small fragments of the clinkers or ironstone derived from the greensand on the west. The same materials, *i. e.* loam or clay with disseminated flints, rise up, in fact, upon the slopes of the adjacent chalk-hills; and thus, as in all the other cases cited, you are insensibly conducted from the debris in the "combe" or hollow to the wider but more thinly spread mass of similar matter on the slopes and summits of the hills.

Again, fossil bones have been found at and near Folkestone, at heights varying from 80 to 110 feet, not in different beds, but always in the same broken-flint-debris. They have also been detected in an upper combe or recess in the chalk-escarpment, nearly two miles west and by north from Folkestone, and at an altitude of not less than 222 feet above the adjacent sea. That spot, called the Cherry Grove, has only to be looked at from the sea-coast to convince any one that its gravel can never have formed a part of the bottom of the same lake or estuary as that in which the Folkestone debris was accumulated. If, however, we imagine a mass of drift transported by a former body of water, the difficulty ceases; and just as the town of Folkestone is now supplied with water from that lofty reservoir or spring-head on the west, so in ancient times may animals and debris have been translated into the deeper cavities of the hollow, or arrested on its sides *.

With the fact before us, that these fossil bones lie at once upon the bare rock *in situ,* without any deposit between it and the drift in which they are commingled, it seems impossible to explain their collocation (even if we put their position out of the question) by supposing that they were tranquilly buried under a lake, or fell from the banks of any former stream. In those cases it would indeed have been miraculous, if ruminants and carnivores had assembled themselves at a particular moment of time to be interred, like a "happy family," in one thin course of detritus, and at the bottom only of the sedimentary matter! To my mind, the circumstances of the same drift being placed at such different levels at Folkestone, and of its sloping up from the sea-board to a height of 222 feet inland, are good evidences that these creatures were destroyed by violent oscillations of the land, and were swept by currents of water from their feeding-grounds into the hollows in which we now find them, and where the argillaceous materials which covered them have favoured their conservation. Nothing can more strongly favour this view than the manner in which fragments of chalk-flints, often angular, are wedged together in the matrix of loam, and enter into the cavities of some of the vertebræ and broken bones of the large quadrupeds. At the same time I presume, that after the great animals in question had perished and were lodged in the depressions and erosions of the rocks, the

* Another fact communicated to me by Mr. Mackie, is the occurrence of a Cetacean bone fifty feet above low-water-mark; and this tends to show how, whilst the drift was translated to the coast, the remains of marine animals, as at Brighton, were occasionally added to the mass of terrestrial animals.

waters may here, as in many other places, have been for some time more or less stagnant over them, and into these I presume that land-shells with mud and sediment were carried from the adjacent grounds.

Here also, as in other places, there are more modern alluvial accumulations, in which the remains of Wolf and Hog occur; but these are in a quite different mineral condition to the fossil bones above mentioned.

Conclusion.

General View of the Wealden Drift Phænomena.—In his able reasoning upon the data of physical disruption which characterize the rocks in and around the Wealden, Mr. Hopkins has inferred that there must have been one considerable, decisive, and simultaneous movement, by which the original and principal dislocation of the elevated mass and the distinctive features of the district were produced*. Admitting that the region may have been first mainly denuded by the powerful operations to which he adverts, my object in this memoir is to show, that at a period long subsequent and approaching much nearer to the present time, when the Weald had assumed its present general configuration, and was to a great extent inhabited by large quadrupeds, there took place other dislocations of so decisive a character, that masses of detritus of the Tertiary rocks, Chalk, and Greensand were cast off and deposited at various altitudes, around the central nucleus, in the fissures of the chalk or on its outward slopes. I beg the reader, therefore, to confine his attention to the phænomena under consideration, and not to mingle them with the antecedent conditions of this region. He will recollect that the memoir commenced by showing, that the whole of the central dome of the Weald has been exempted from the drift to which attention is called, and that together with such exemption it has not been found to contain any remains of the great fossil quadrupeds†. He will further have noted that evidence has been cited to prove that, when the drift containing the bones of the fossil animals was deposited, the valleys had to a great extent assumed their present form, and that the vast volumes of water which must then have occupied them, had in many instances a general reference to the slopes and depressions in which the present puny rivers meander at great depths beneath the surface of the ancient currents; although in some cases the old drift has been carried *up* the present valleys (see p. 382).

However we may attempt to separate the superficial drift of other parts of England into distinct masses formed at successive periods, enough has been said to show, that there are great difficulties in doing so in this south-eastern region. But here I must not be misunderstood. There are, indeed, many places in the South-east of England where the surface of the Chalk has been deeply eroded (as is well exposed in the vertical beds of the Isle of Wight), and its cavities filled in by the

* Trans. Geol. Soc. Lond. N. S. vol. vii. p. 43.

† I still think it possible, however, that bones of the large extinct Mammalia may be found under some of the local silt and loam of the Hastings Sands.

detritus of our earliest British Tertiary age. The superficial debris to which I have wished to restrict attention is carefully to be distinguished from that more ancient form of drift; and this has been done by showing that Tertiary formations have themselves been broken up by the disruptions alluded to, and their debris mixed up with the drift in question.

The prominent object I have had in view was to impress upon the mind, how a period of perfect quiescence and ordinary causation along the southern shores of England, as proved by the round water-worn pebbles of the Brighton shingle-bed, was suddenly succeeded by a tumultuous accumulation of angular drift, which, having necessarily resulted from violent action, can, I think, be only well explained by reference to some of the last powerful fractures of the Chalk and overlying Tertiary strata. Now, these sharply-contrasted physical features of quiescence and turbulence pertain albeit to one and the same epoch of life. The quiet sea-beach was accumulating, and the same great animals were living, with marine species of shells still existing, when a catastrophe occurred which destroyed many of the former.

On reference to the Wealden as a whole, and where it extends into France, I am indebted to my friend Mr. Prestwich for indicating a fact of great interest, hitherto unnoticed, and on which I hope he will give us his views *in extenso**. In examining the coast-cliffs of France to the south of Calais and its dunes, he found at Sangatte, which lies in the eastern prolongation of the phænomenon described at Folkestone and Dover, two deposits exactly resembling those of Brighton, *i. e.* an underlying water-worn beach and a superior pile of sharply-fractured tumultuous drift.

I wish therefore that the eminent naturalists who have given us such good grounds for believing † that England must have been separated from France since the period of the great diffusion of pliocene animals, may see, as I do, in the physical facts cited, the proofs that, in the region under consideration, many at all events of these creatures were destroyed by the sudden and violent operations I have described, and may admit that they did not all pass out of existence by ordinary and gradual causes.

It would, however, be erroneous to suppose, that all the fragments of the drift of this period are in the same angular condition as that of Brighton, Lewes, and the South Downs. The result has been somewhat different in respect to the drift of the same materials which were thrown off northwards from the North Downs into the depression which is now the valley of the Thames. In that tract many of the flints are more water-worn, as may be well seen in Hyde Park, Kensington Gravel Pits, and numberless spots on both banks of the Thames, as well as under London itself. This difference in the form of the same materials might be accounted for by supposing that where the flints did not proceed from any lines of fracture, but simply from the slopes of the chalk, they would necessarily be less fractured. Again, we may imagine that the detritus shed off north-eastwards

* See Mr. Prestwich's Paper, read June 25, 1851, *supra*, p. 274 *et seq.*

† See particularly Owen's History of British Fossil Mammals (Introduction).

found its way into a broad torrential river or estuary between the Surrey and Hertfordshire hills, in which fluviatile action afterwards prevailed, so as to wear off the angles of the fragments which had been hurled into it. My own opinion is, however, that nearly all this rounded flint-gravel was derived from the breaking-up of the old tertiary pebble-beds (as explained p. 374), which were infinitely more developed in the London tertiary basin than in that of South Sussex and Hants; in other words, that the rounding of the flints in the gravel was an operation of the early Tertiary Period. At all events, from the slopes of the South Downs to the sea where very few rounded tertiary pebbles have ever existed *in situ*, we clearly see that after the first rush of waters, whether down the talus of the chalk or through lateral openings, the fractured flints must have been left as originally piled up, and, being desiccated, have never more been subjected to the action of water and have remained in their angular state.

Let me here remind the reader, that if shocks of earthquakes in this and the other hemisphere of which we have historical records have occasioned the rise and fall of great waves, so such dismemberments as those in question will much more readily enable us to form an idea of the transporting influence of ancient volumes of subterranean water resulting from convulsions that opened out chasms in the crust of the earth infinitely exceeding anything known in the historical era.

In reverting, then, to the chief point in this memoir, I would repeat, that the principal and upper masses of debris which are spread out on the external slope of the South and North Downs, or within the Wealden denudation, must have been suddenly translated, and as suddenly accumulated, in the rude piles or infillings of cavities they now occupy; since no analogy of tidal or fluviatile action can explain either the condition or position of the debris and the unrolled flints and bones. On the contrary, by referring their distribution to those great oscillations and ruptures by which the earth's surface has been so powerfully affected in former times, we may well imagine how the large area under consideration was suddenly broken up and submerged. This hypothesis seems to me to be an appeal to a *vera causa* commensurate with the results. As respects the South-east of England, the operation must have been modern in a geological sense; for our present line of sea-coast had then been formed, our lands, including great longitudinal valleys in the Weald, were tenanted by herds of great quadrupeds: whilst even anterior to the catastrophe by which such land-animals were destroyed, sea-beaches of rolled pebbles, containing species of molluscs still living, had previously been accumulated on our southern shores, together with some remains of extinct quadrupeds which had been derived from the adjacent lands! In short, the cliffs of Brighton afford distinct proofs, that a period of perfect quiescence and ordinary shore-action, very modern in geological parlance, but very ancient as respects history, was followed by oscillations and violent fractures of the crust, producing the tumultuous accumulations to which attention has been drawn.

I may here further remind geologists, that the great line of dislocation of the Wealden and its subsidiary parallels in the flanking hills, when continued to the west, is coincident with the axis of the Vale of Pewsey. This line is further parallel to the axis of the Isle of Wight and to many other lines of fracture in the South of England and South Wales, along which great disturbances have also occurred at the same comparatively recent epoch.

Generalization of British and Foreign Drift Phænomena.—Let us now endeavour still further to generalize the subject of the local angular flint-drift of the South-east of England, by comparing it with analogous phænomena in other parts of the world.

On a former occasion*, I showed that the commencement of the first glacial period in the history of the Alps was synchronous with an enormous dislocation and upheaval of that chain, and coincident with a vast change in the level of materials constituting the then existing land and their debris, which had previously lain beneath the waters. I also maintained, that such dislocation was of the same date as that which submerged a pre-existing northern continent and brought it under the influence of an Arctic ocean. The proofs of a sudden and violent change being, as I think, as well demonstrated at our own homes, my conviction is, that here, as in the Alps, one of the first steps in that great climatal revolution was accompanied by very extensive fractures and changes of level in large portions of the crust of the earth. At the same time we may fairly infer from other testimony, that the first vibration which elevated some tracts and depressed others having once passed away, subsequent accumulations were continued in Northern Europe under glacial conditions during a very long period, including, as I am ready to admit, the existence of terrestrial glaciers at certain points in Britain (of which Snowdon is an example) on islands of no great altitude in a glacial sea. Thus, we may explain the position of copious masses of subaqueous detritus, and the transport of huge erratic blocks from such terrestrial centres. In this sense, the drift of Britain which has travelled from the North, and the Alpine drift and blocks of Bavaria and the Jura which have proceeded from the South, belong to the same great geological epoch, or the first period in the chronicles of the planet in which we have distinct signs of glacial action.

Prior to the origin of that glacial time, and, according to my view, before England was severed from the Continent, the great extinct quadrupeds had doubtless spacious feeding-grounds commensurate with their abundance. As long as they flourished, these animals must have contributed their remains from year to year to fluviatile, lacustrine, and estuary deposits; and therefore it is, that in some places we may find their bodies in such stratified masses; although it is manifest that by far the greater number of those creatures which died a natural death must have disappeared (bones and all), when not imbedded under some impenetrable sediment. This fact, however, is perfectly consistent with the contrasting and collateral evidence which compels us equally to believe, that the destruction of a multitude of those animals along

* See Quart. Journ. Geol. Soc. vol. vi. p. 65 *et seq.*

certain bands of the earth was equally due to the violent and sudden fractures, heaves, and immersions (not mere upheavals) to which such tracts were subjected. I believe this, not only from the proof so clearly afforded of parent rocks having been then split up and of their having thrown off quantities of angular debris, but also from the occurrence of the heaps of fractured bones of our aboriginal Oxen and other Herbivores which are piled up in confused masses in the mud, clay, sand, and pebbles in the deep clefts and fissures of many of our clean-denuded rocks. The hills, in short, have been swept, and the hollows have been filled.

On the other hand, just as the water-worn and raised beaches of the coast indicate a previous tranquillity and long-continued ordinary action, so the caves which were first inhabited during former ages by Hyænas and other quadrupeds, prove to us the lengthened period of quiescence that prevailed upon the land anterior to the grand convulsions under consideration, and by which, as I think, the cold or icy period was ushered in.

On fair evidences we may also infer, that a long epoch followed the physical changes in question, in which glacial conditions both subaërial and subaqueous prevailed in the Northern hemisphere. But even during the great oscillations which preceded and accompanied such glacial epoch, including the re-elevation of vast sea-bottoms into continents, there are proofs that many of the former great animals escaped destruction; doubtless by taking refuge on lands unaffected, one of these having been preserved alive to our present time in the *Bos Aurochs* of Lithuania *. This fact will account for another epoch of cavern-animals subsequent to the glacial epoch, as indicated by Professor E. Forbes †.

Nothing indeed is further from my wish (and all my writings testify it) than to inculcate the belief that the former changes of the surface, however they were in my opinion more paroxysmal and grand than any of our era, were ever so general as to destroy whole races of animals. I have invariably contended that all physical disruptions of the crust are local. In this sense each drift is local and must have reference to its own cause. On the other hand let me say, that the endeavour to refer all former fractures of the strata as well as their overthrow on a great scale, as in the Alps, to causes of no greater intensity of action than those which now prevail, is in opposition to the observations I have made in every mountain-chain, as well as in the modest cliffs of Brighton and Dover.

Surely practical geologists can easily draw a distinction between the quakes which the earth now undergoes or has undergone in the historic era, and the profound rents and enormous changes of level to which it was subjected in former periods.

My conviction is, that, by including all ancient geological phænomena in the category of existing intensity of causation, the able men who have espoused that view have, in their too great eagerness to explain much that is still obscure, forced the former energy of nature

* See Russia in Europe, vol. i. pp. 503, 638.

† Memoirs of the Geological Survey of Great Britain, vol. i. p. 394.

into a quietude which is inconsistent with the proofs of her violent revolutions.

It is in this sense that I view the tumultuous accumulation of the Brighton breccia, the translation of detritus to its present positions between the chalk escarpments and the central dome of the Wealden, and the discharge of materials from the transverse valleys, or down the outward slopes of the chalk, as all of them antagonistic to the inference, that any of these results could have been accomplished by the ordinary long-continued action of water.

Even in our own isles, but in tracts removed from the South-east of England, the same materials of former masses of sea-gravel and sand, and the same species of sea-shells contained in them being arranged in different terraces at altitudes varying from 10 to 1500 feet above the sea, is sufficient proof that the vibrations which produced the present outline were of very unequal intensity, at points little distant from each other and in the very same region.

This memoir refers, I repeat it, only to the last great surface-operations in and around the Weald. But, if for a moment we carry back our imagination to much earlier states of things, and reflect upon the manner in which the rocks must have here been broken athwart in the original formation of the river-courses or transverse valleys, we may rely on the coincidence so clearly indicated by Mr. Hopkins as existing between those natural features and the mechanical results of the strain and rupture of a great ellipse of elevation. There seems indeed to be no escape from his inference, that such transverse fissures, or their deepening and extension, were immediately dependent upon or the direct resultants of the formation of the main longitudinal axis of elevation. These views render it still less possible to refer the former grand denudations of the Weald to the ordinary action of the sea than the last translations of its local drift. If an arm of the sea had permanently occupied this tract during each of the long periods in which the advocates of gradual causation suppose the strata to have been successively broken, crumbled down, and washed away *, we ought to find some relics of the water-worn shingle, of former times, along the numerous escarpments of Upper and Lower Greensand, &c., if not along the edges of the escarpments of the chalk or chief shores of former seas. But if not along those main shores, the narrows by which the great bay communicated with the ocean (for such the transverse valleys must in that case have been) ought specially to present to us lines of water-worn shingle, something like the beaches of our own coasts or the raised terraces of Norway. We ought, at all events, to be able to detect as good evidences of the former abode of the sea as are observable in the valley of the Severn or former "Straits of Malvern," and other parts of England, where sea-shells and shingle coexist †. On the contrary, we find that, in accordance with the view of great denudation and translation of materials, it is just in such gorges that there are patches in the recesses, not, however, of the rounded materials which long-continued tidal action of

* See Lyell's Manual of Elementary Geology, 1851, p. 242–257.

† See Murchison's Silurian System, p. 530.

waves would produce, but of irregularly formed angular or subangular flint-gravel and drift, not bedded and arranged at definite heights above the present drainage, but arrested at various altitudes or lodged in the lowest depressions; *all the remains which can be detected in them being exclusively terrestrial*, except on the southern sea-shore. Occasionally, indeed, the drifted materials are found dovetailed into the cavities of the fractured bones, and land-shells of existing species are found in the loam commingled with the lost species of quadrupeds.

In this view, the flint-debris of the Wealden or of the transverse openings belongs to the same great turbulent era of fracture and translation as the materials of the Brighton Breccia and of the slopes of the South and North Downs. For, although the currents must have been severally modified according to the form of the land, and the detritus must have been more angular when removed to a short distance only from a line of fracture, there are no evidences in the South-east of England to indicate that these violent operations were suspended, to be succeeded by ordinary tidal action, and then to be repeated after a long interval; or, in other words, that the drift can be divided into two or more classes; although it is so clearly separable, as to the method of accumulation, from the much water-worn sea-beaches that preceded it. Yet, whatever doubt may be entertained on this point, and however it may hereafter be found to be capable of subdivision, there can be little in affirming, that neither during the operations which deposited the debris, nor after them, was the Weald valley occupied by the waters of a sea, or its transverse gorges by marine narrows.

There is not a single rounded pebble along the lower edges of any of the escarpments that flank the central Wealden; still less does the tract contain any fragments of marine shells; whilst by far the greater part of the detritus is just that which must have resulted from an action which left the shattered debris in positions and conditions which no ordinary sea would have done. Nor can it be suggested, that along hundreds of miles of natural escarpments, the supposed lines of deposit of ancient sea-shores are all now hidden under spoil resulting from the diurnal action of ages. The rocks *in situ* are everywhere at or near the surface, and nowhere is there any symptom of action of the sea. Again, all the fossils found inland are terrestrial.

I dwell upon this point because it has a very wide application. I am indeed bound to express my conviction, that, if inapplicable to the Weald, the hypothesis of denudation by the sea will still less apply to the much grander denudations of the Old Red Sandstone of the Highland Mountains and many other similar phænomena. Whilst I quite admit with Sir Charles Lyell "that all deposition is the sign of superficial waste going on contemporaneously and to an equal extent elsewhere," I also believe, that the crystalline matter which has been protruded to the surface of the crust of the earth in the plutonic and volcanic rocks, and which certainly rose from beneath, occupies even now immense superficial areas. Each of these former igneous evolutions (many of which are now hidden from our sight by depositions of younger formations and of detritus) were undeniably sudden additions from within to the outer crust, and not mere subtractions from one spot and additions to another. Without such an extensive internal agent in a former condition of the planet, the geologist would indeed be sorely puzzled to explain how many of the earliest sediments began to be formed. Once admitted however, and he has no difficulty either upon this head or upon the disruptions specially under consideration. For if, as I believe, the agency from within was then much more intense and prolific than any which now prevails, so can we very well imagine how the ruptures and oscillations of the crust were greater, and how the translation of materials on the occasion of such changes was more violent and dispersive than anything of which we can form an opinion from actual observation.

The other hypothesis, by which incalculably vast masses of the hard rocks that once filled mountain gorges or broad valleys were gradually ground down and removed by the ordinary action of the sea, is inconsistent with the facts above narrated. Still more is it set aside by an appeal to the great fractures which have affected so many other parts of the earth's crust; for these prove that the agency by which many geological revolutions were effected was as abruptly violent, as the increase of sediment during long ages of repose was gradual and analogous to what is now going on.

In maintaining, in common with many other writers, that there was a much greater intensity of fracture in former stages of the planet than now, I also infer, that such dislocations must have been accompanied by torrents of water then set into play; which, whether they may have been salt, and be called waves of translation, or fresh, and were obtained from subterranean sources, must have powerfully aided such sudden strains and fractures, and thus have effected in a short time that which under ordinary circumstances could not have been done in thousands of years. Any ordinary tidal action we can conceive would, I repeat, have left signs either of successive sediment or of water-worn pebbles, and would not have afforded the clear proofs that have been adduced either of sweeping denudations down to the bare framework of the rocks, or of angular drift distributed in bands and patches at various altitudes. In accounting for such facts, the advocate of the tidal action of the sea meets with insurmountable difficulties at the very threshold of his position. Instead of rounded pebbles in the last-formed detritus of the South-east of England, he sees both on this and ón the other side of the Channel near Calais, that where there is a true water-worn beach, it lies beneath local drifts, in which all is fragmentary and tumultuous; and hence he is not authorized to appeal to the mere forms of the escarpments of chalk, or to insulated pyramids or outliers of that rock, as proofs that the sea, as we now understand its action, could have produced any such results. We, who take the opposite view, assert, that the shattering and breaking down of rock-masses by upheavals and depressions, were the first steps in accomplishing such ends, and that the sudden action of waters incident on such great oscillations was the chief denuding agent, and simply left the outline of the rocks when desiccated to be acted on for after-ages by diurnal atmospheric action.

Nor have we, in discussing the question of the Wealden denudation and the formation of its local drift, the power of invoking the agency of ice, as in the more northern tracts of England and Scotland and over large portions of Ireland. Here we cannot appeal to terrestrial or sea-borne ice, to get rid of the difficulty of tumultuous accumulation, by supposing that icebergs impinged upon alluvial matter. For no one has yet ventured to suggest, that the heights of Butser, Hind Head, or Leith Hill were the abodes of glaciers, nor has any one detected appearances in the drift within or without the Wealden area which can be considered to have resulted from the mechanical action of ice; still less have any species of arctic shells or far-transported blocks ever been observed within the area affected.

The natural impression, therefore, is, that the last great ruptures and denudation of the Wealden being completed, this tract was shut out and excluded from the influence of that boreal sea, of whose former effects, including the powerful operation of floating ice and frozen mud and stones, there are such clear signs over wide spaces in Scotland, Ireland, and Wales, as well as over large northern portions of the Continents of Europe and America.

Such general drifts are to be considered as distinct from the local, angular flint-drift of the South-east of England.

In sustaining these views, I have simply endeavoured to substantiate by an appeal to physical evidences, that, as many species of quadrupeds doubtlessly passed away by gradual extinction and long-continued ordinary causation, others were suddenly destroyed by local oscillations and violent fractures of the crust of the earth, and were entombed in drift accumulated under transient volumes of water. For, whilst it is our special duty as geologists to examine the drifted materials of each country in reference to its own phænomena, we must not forget that the very same species of fossil quadrupeds, as those to which I have been adverting, have also been buried in the gold-bearing drift of the Ural Mountains and Siberia, as well as in the coarse detritus of similar age covering other large portions of the world, which also has been accumulated under a much more powerful agency and much more copious volumes of water than have since affected those lands. It is manifest, therefore, that however the subsidiary causes may have been local and diversified, there was a very general destruction of great terrestrial animals during the period in question. In a word, Geology teaches that slow and long-continued accumulations have been succeeded at various epochs by violent dismemberments, and it is to one of the last of these periods of great revolution that attention is now directed.

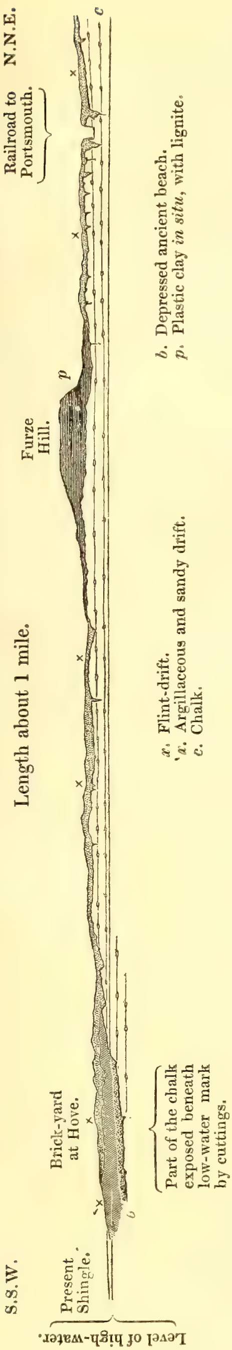
Postscript.

Although I have expressed my opinion, that the upper heaps of unstratified, angular, or unrolled flints, which vary in thickness from 2 and 3 to 25 feet, resulted chiefly from one operation, I fully admit, that in some situations (particularly along the Sussex coast) the lower members of the drift have been accumulated under aqueous conditions of less violence than the overlying broken flints. In short, I believe that the period of the drift of this region was one during which several vibrations and oscillations of the surface followed each other, whilst the lands were tenanted by large quadrupeds now extinct, and the testacea of the land and sea were those that now prevail in the same latitude. The sections of the clay and flint-drift between Brighton and Hove, that have been mentioned p. 367, sustain this view. Since the memoir was printed, fresh excavations for brick-earth have completely substantiated the fact, that however much the clay under the angular flints may there have a tertiary aspect, the whole is of the same modern or post-pliocene age, through a thickness of upwards of 40 feet. The following is a detailed section of the subsoil as recently cut into; but it must be understood, that no one of the masses described is persistent in a horizontal extension for more than a few yards, and that each of them is capriciously distributed.

	Ft.	In.
1. Upper loam and angular flints, the latter much prevailing; void of all traces of bedding, and filling tumultuously very irregular depressions in the clay below. (Angular flint-drift) .... 8 to	13	0
2. Brownish, ochreous brick-earth with some sand, an occasional small fragment of chalk or flint, a tertiary pebble at rare intervals, shells of *Littorina* here and there, and few traces of bedding...............	17	0
3. Sandy bluish clay with highly fractured bones of Hippopotamus? and teeth of Horse, Stag, &c.; and sea-shells of the species *Littorina littoralis* and *Mytilus edulis* (the latter preserving its colour), much fractured, chiefly at the bottom, and resting on the upper "shingle." The matrix is evidently the residue of a tertiary clay in which some *Cerithia* are still discernible	4	0
4. Coarse "shingle" of unrolled chalk-flints not much fractured, and looking as if they had been moved a short distance only; with a few pebbles of granite ....9 inches to	1	3
5. Sands of ochreous, white, and grey colours, with occasional fragments of sea-shells near the top, and with rare large waterworn pebbles ....1 foot to	7	0
6. Lower "shingle," of the same materials as the upper shingle; the pebbles rounded and small, varying from 2 to 8 inches in size, much waterworn...9 inches to	1	3
7. Chalk-breccia of small thickness.		
8. Chalk with flints, in which a strong spring of water rises at 4 feet below the surface.		

The two courses (4 and 6) of "shingle," as they are called by the workmen, between Brighton and Hove, constitute, with the interpolated sand (5), but one stratum only, which is clearly the equivalent of the old beach of Kemp Town. A few of the same pebbles which occur in the upper and lower shingles are found at intervals in the fine sand, and where the latter thins out, the two pebble courses are united. The clearest proof of the identity of the Hove shingle-beds with the old beach of Kemp Town consists in the admixture in both of granitic rocks with large chalk-flints, all more or less waterworn, and perfectly distinct from every portion of the superior accumulations. Now, this one and the same former beach, which is everywhere recumbent on the bare chalk, is about 24 feet *below* high-water mark at the west end of Brighton (see Woodcut, fig. 11), and not less than 15 or 16 feet *above* the same level at the Preventive

Fig. 12.—*Section of the Plastic Clay at Furze Hill, and of the Drift West of Brighton.*



Station, Kemp Town. This fact, which proves that the coast-line underwent an oscillation of 40 feet at so recent a period, in a space of two miles, will, it seems to me, account satisfactorily for the tumultuous accumulations which followed, and particularly for the sudden transport of the angular flint-drift above the beach so affected; the overlying blue clay, yellow clay or brick-earth, and the heaps of flint being all, according to my view, parts of the drift which were successively accumulated along the shore, in one and the same period, which terminated with great violence.

Another new feature of interest has been added to the descriptive geology of the environs of Brighton by a recent excavation for brick-earth on the north side of Furze Hill (Wick), which proves that this spot of high ground, the property of Baron de Goldsmid, to which the western part of the town is now extending, is composed of Plastic-clay *in situ*, and not of the re-aggregated drift-clay just described, which so prevails in the flat grounds along the Sussex coast. I had doubts on this point (see p. 367), and they have been removed by visiting the new cuttings accompanied by Mr. John Carrick Moore and Mr. D. Sharpe. From 15 to 20 feet of mottled plastic-clay with courses (one of which is 3 feet thick) of black bituminous earth, in parts a lignite, have been clearly exposed. This clay differs essentially from the drift-clay that has been derived from it, in containing no fragments of flint or chalk, and is therefore of superior value for the manufacture of bricks. It contains yellow decomposing iron-pyrites, which gives origin to a mineral water, having the same acrid taste as that of Alum Bay in the Isle of Wight; and there is little doubt that the adjacent saline chalybeate of Wick owes its chief properties to the same stratum. Numerous openings of the surface for the foundations of new houses, around this hill of plastic-clay, expose either the chalk with flints, or that rock covered by a few feet of re-aggregated stiff loam with some coarse unrolled flints mixed up in it. This mass of Plastic-clay is, therefore, as complete an outlier as that of Patching before described (p. 372). It has appeared to me desirable to explain the general relations of the drift to the chalk and older tertiary deposits *in situ* at this western end of Brighton, and to illustrate them by the accompanying woodcut, fig. 12.

I have only to add that I have just received, together with the revise of this postscript, a copy of a memoir, by Mr. Martin of Pulborough, on the "Anticlinal Line of the London and Hampshire Basins," recently published in the Philosophical Magazine, 4 Ser. vol. ii. 1851, in which I rejoice that his paper on the "Probable Connexion of the Eastern and Western Chalk Denudations," to which I have adverted as having been mislaid at the Geological Society, has at length been printed. I much regret not to have had access to a production, so pregnant with original observations on the anticlinal and synclinal lines of the South of England, and which would have enabled me to enforce more cogently some of the arguments I have endeavoured to advance. The reader who may collate my deductions concerning the drift with those of Mr. Martin will see, that whilst I agree with him in the manifest proofs of violence in the dislocation of the rocks and the sudden and tumultuous translation of a large portion of their debris, I am not of his opinion that the denudation of the Wealden and of its flanking ridges was the result of one grand operation only. I have to express my regret, that I should have been unaware of Mr. Martin's previous description of the outlier of tertiary clay and pebbles at Highdown Hill, Patching (Phil. Mag. 4 S. vol. ii. p. 191), which I have described above, p. 372; but I entirely adhere to the view first taken by Dr. Mantell, that the waterworn and rounded shingle under the drift at Brighton is of the modern age he assigned to it, and that it cannot be assimilated to the remnants of the older tertiary pebble beds which have been left here and there upon the surface of the Chalk Hills.

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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 ARSENIOUS ACID, REALGAR, *and* ORPIMENT. By Prof. HAUSMANN.

[Karst. und Dech. Archiv für Mineral, u.s.w., 1850, vol. xxiii. p. 766.]

ARSENIOUS acid is known to occur in two forms, crystalline and amorphous. These two isomeric states are distinguishable not only by outward appearance and physical characters, but also by a different chemical constitution, evidenced by their different solubility in water. The amorphous arsenious acid when recent is a glassy substance, characterized by conchoidal fracture, vitreous lustre, and transparency: the differences of hardness and specific gravity, usually observed between the crystalline and amorphous varieties of a substance, are perceptible in the two forms of arsenious acid. Karsten, who has made such exact experiments on the specific gravity of so many simple bodies and their combinations, has fixed the specific gravity of arsenious acid, procured by sublimation, at 3·7026, whilst he found that of the acid, procured by digesting arsenic in nitric acid and washing it out with water, to be 3·7202. The difference is still greater in hardness; since the hardness of the amorphous acid is equal to or even surpasses that of calc spar, whilst that of the crystals is scarcely greater than that of gypsum, and in some varieties is even intermediate between gypsum and common salt.

Arsenious acid is sometimes found native. It has frequently been confounded with pharmacolite, which it strongly resembles; and although in later mineralogical works it has been separated from that substance under the name of Arsenik-blüthe, yet other mistakes have crept in, from not distinguishing between the amorphous and crystalline forms. To this is to be attributed the contradictory statements of the hardness and specific gravity which occur in the latest works on mineralogy. Kobell, in his 'Principles of Mineralogy' in 1838, puts the hardness of arsenious acid at 3·5, which accords with the greatest hardness of the amorphous acid. The newest edition of the physiographic division of Mohs's 'Principles of the Natural History of the Mineral Kingdom,' by Zippe in 1839, gives the specific gravity 3·698, as determined by Roger and Dumas, which refers to the transparent arsenikglas; whilst the hardness, which is called 1·5, belongs to the softer varieties of the crystallized acid. In some works the numbers are in excess. Breithaupt in his 'Hand-book of Mineralogy' for 1841, puts the hardness at from 3 to 4, which agrees with 2·5—3 of Mohs, and which exceeds not only the hardest varieties of the crystallized but also of the amorphous acid. The specific gravity given in the same work belongs only to the latter. Fuchs in his 'Natural History of the Mineral Kingdom' for 1842, compares the hardness of arsenious acid to that of calc-spar, which is true of the arsenikglas, but is never reached by the crystallized acid. Haidinger in his 'Handbook of Mineralogy' for 1845, gives 1·5 for the hardness, and 3·6—3·8 as the limits of the specific gravity, within which both varieties fall. I have to acknowledge that in the new edition of my 'Mineralogy,' in describing arsenik-blüthe I neglected to notice this distinction between the amorphous and the crystalline forms.

Most of the varieties of arsenik-blüthe, which in nature is usually found as a secondary product in veins containing arsenic and arsenical salts, belong to the crystallized form; for although perfect and pure crystals are very seldom met with, yet the crystalline form may be more or less distinctly observed in the foliated, acicular, or capillary structure. Only the pulverulent variety, found in the Katharina Neufang Mine at St. Andreasberg, and possibly some stalactitic varieties found elsewhere, can be looked on as amorphous. This variety under the name of arsenikglas must be separated in our system from arsenik-blüthe as a distinct species; and upon the same grounds on which opal is separated from quartz. Greater hardness and increased solubility in water give arsenikglas distinct characters, independent of the want of crystalline form.

Besides the products containing arsenious acid which are made designedly by metallurgic processes, this substance is sometimes accidentally formed in the furnaces, both amorphous and crystalline. More or less perfect crystals are formed not unfrequently in roasting arsenical ores, and as products of the furnace, as is the case at the furnaces at Ocker, near Goslar, and at St. Andreasberg. Crystals are sometimes formed in the walls of the furnaces in which arsenical ores have been smelted, or such as accidentally contain arsenic. I possess specimens from the silver furnaces of St. Andreasberg and from the copper furnaces of Reichelsdorf, in which latter the arsenious acid is found in the upper part of the 'schiefer-ofen' even in the fibrous state. In roasting the furnace-products containing arsenic, sometimes arsenikglas is obtained in the form of incrustations and stalactites.

The most remarkable property of arsenious acid incontestably is this, that as an amorphous body, without any admixture, and without losing its solid state, it experiences a change which makes it assume a totally different aspect. It has long been known from experiment that the transparent arsenikglas gradually becomes opake, until it resembles porcelain. The substance at first colourless becomes white, the transparency disappears, and it becomes completely opake; the beautiful vitreous lustre becomes feebler and approaches the waxy. According to the experiments of Taylor and of Guibourt, the specific gravity at the same time diminishes. The former found that of the transparent acid 3·798, and of the opake 3·529. The latter made the specific gravity of the transparent 3·7385, and the opake 3·695. The hardness also is subject to change, the gloss sometimes becoming pulverulent, so that its fracture is earthy and the lustre quite gone.

Fuchs in his beautiful work on Amorphism has thrown out the conjecture that the glassy arsenious acid loses its transparency by virtue of a gradual change into a crystalline mass. Again, in his 'Natural History of the Mineral Kingdom,' he asserts it distinctly; for he says that the amorphous arsenious acid in time becomes white, opake, and porcellanous, and also becomes pulverulent, so that it can scarcely be recognized as crystalline. In order to ascertain whether the crystalline structure could be detected in the altered arsenikglas, I have examined the crumbling outer crust under a magnifying power of 400, but could not perceive any trace of it. Though this experiment seems opposed to this view, yet I have been lately satisfied of its truth in the most convincing manner. In the year 1835, I received from the silver furnaces of St. Andreasberg, through the kindness of the director Herr Seidensticker, (to whose management the arsenic works there owe their excellence,) a specimen of the arsenikglas manufactured there, about two cubic inches in size, which he had broken off with his own hands immediately on opening the still warm apparatus, and had caused to be instantly packed up that it might arrive as little injured as possible. The specimen, as I received it, had a distinct conchoidal fracture, without a trace of crystallization; it was transparent and colourless, and altogether of a glassy appearance. I laid it by in a drawer of my mineralogical collection, in a dry situation close to my dwelling-room. A long time passed before I had leisure to lay my hands on it again; when I did so some years after, its appearance was surprisingly changed. Not only was the principal mass become porcellanous, but also on the opposite sides the parts next the surface had lost their clean conchoidal fracture, and to a depth of two lines had adopted an acicular structure, so that the surface seemed rough and cracked. This change excited my surprise, which was greatly increased when at the end of a few weeks I found that not only had this acicular structure proceeded further, and reached a depth of four French lines in some places, but also that the exposed side of the acicular masses were studded with a great number of distinct octohedral crystals (!); some of these crystals were half a French line in diameter. They were collected in small clusters, so as to give the whole surface a drusy, intumescent appearance. The acicular-shaped parts of the crust which were at right angles to the surface passed insensibly into crystals, the groups of which seemed, as it were, to be pushed out beyond the surface. The crystals were white like the rest of the mass, but more lustrous and more translucent.

Such a transformation of arsenikglas into a mass of well-formed crystals is a most remarkable instance of molecular change in a rigid body, and is the more striking, since apparently it is not caused by any exterior circumstance, nor is attended by any change of constitution. It would seem that the molecules are put in motion by a tendency of the amorphous mass to pass from the condition of tension to that of repose and equilibrium, which is the characteristic condition of crystallization. This remarkable change also proves that nature can accomplish in time what she cannot effect in a shorter space; a truth deserving to be remembered in all physical inquiries, and especially in geology.

Some years after I received from the silver-mines of St. Andreasberg a piece of arsenikglas recently formed, which I placed in my collection near the specimen before described. It has also now acquired a porcellanous appearance, but has preserved a perfectly smooth surface. I broke it across in order to ascertain the condition of the interior. The inside is still perfectly glassy, the exterior only being changed. It is also to be observed that the change from without inwards has proceeded very differently in different parts. On one part of the surface the thickness of the unchanged crust is scarcely appreciable; while in other parts the porcellanous mass (in which the large-conchoidal fracture is changed into uneven, small-conchoidal) is two lines thick, with its interior limit ill-defined. From this it seems to follow, that in very similar masses of arsenikglas there are certain differences of aggregation, which cause them to differ in their progress towards becoming opake. On this it may depend, as well as on other determining causes, that generally the amount of change is independent of the length of time elapsed. For it is possible that arsenikglas might be kept a longer time than the piece I have described without exhibiting so remarkable a change.

These observations on arsenious acid induced me to make some inquiries in order to understand better the relation of crystallized sulphuret of arsenic to the amorphous glass consisting of sulphur and arsenic. The native realgar has the property of not melting to a glass, but to crystallize in cooling. I exposed some compact realgar from Tajowa in Hungary to a melting heat, over a spirit lamp, in an iron spoon. It melted readily and contracted suddenly in cooling, and formed small separate drusy masses studded with crystals. When melted in a glass tube it forms deep concavities in cooling. The surface immediately in contact with the glass has a fibrous structure, the fibres being perpendicular to the exterior surface, while the inner space is furnished with small crystals, in which the klino-rhombic system is more or less clearly expressed. I kept a portion of realgar in a closed tube at a melting heat for four hours, in order to see whether the crystalline condition would not be changed into a vitreous one by continued fusion; but as before, small white crystals were formed in cooling. The slower the cooling process was, the more distinct and larger were the crystals; but even a sudden cooling by throwing the melted mass into water does not destroy the crystalline action. These considerations caused Wöhler to produce an artificial realgar by melting together 1 equivalent of arsenic and 2 of sulphur, which proved as crystalline as the masses produced by melting native realgar.

I received from Herr Seidensticker a compound of sulphur and arsenic produced by sublimation, which in colour, the colour of its powder, and in fracture resembles native realgar. In its small drusy cavities there are crystals, but these appear under the lens to be regular octohedral crystals of arsenious acid coloured by sulphuret of arsenic. This product when fused in the glass tube neither becomes crystallized nor vitreous, the fracture is imperfectly conchoidal, or uneven, with a slightly waxy lustre. The mass contracts and cracks, but shows no sign of crystallizing. On the concave surface small white brilliant crystals of arsenious acid show themselves.

The red arsenikglas of commerce, which also passes by the name of realgar, shows by its colours that the proportion of its arsenic to the sulphur is small, as must necessarily be the case from the mode of preparation. It has a very perfect, large-conchoidal fracture, a vitreous lustre sometimes approaching the waxy, and is only transparent at the edges. Its specific gravity is always less than that of native realgar. The latter as determined by Karsten is 3·5444, whilst the former, according to experiments of my own made with distilled water at a temperature of 15° R., ranges between 3·20 and 3·32 ; that of a specimen from the silver-mines of St. Andreasberg being 3·318 ; a dark red specimen purchased here being 3·258 ; and one of a beautiful bright red colour from Ehrenfriedersdorf being 3·254. The hardness of the arsenikglas on the other hand is much greater than that of native realgar, that of the former being equal to calc-spar, while the latter only reaches 1·5. The red arsenikglas when fused still retains its vitreous character, and even when very slowly cooled shows no trace of crystallization. The lower specific gravity seems to indicate that when produced in large quantities it has usually a greater proportion of sulphur than native realgar. This is confirmed by the fact, that by fusing native realgar with orpiment (Rauschgelb) a substance is produced closely resembling the red arsenikglas of commerce. A large addition of orpiment to the arsenikglas while in fusion destroys the tendency to crystallize. Moreover the mode of preparing the red arsenikglas justifies a belief that a smaller proportion of arsenious acid is present. At all events, the red arsenikglas cannot be looked on as identical with the crystalline realgar composed of definite proportions ; and the assertion that realgar is a vitreous substance, which occurs in modern manuals of Chemistry, must in future be rectified.

Orpiment or Rauschgelb, which is so well marked a crystalline substance by its very perfect foliated cleavage, differs strikingly from realgar, with which it often occurs mixed in nature, in this respect, that when fused it passes into an amorphous mass. The glass thus produced has not its original yellow colour, but is more or less bright red. Karsten has already remarked that the change of colour may arise from a change in its flexibility. If the fusion is carried on in close vessels, the result is a semi-transparent glass of a ruby or hyacinth-red colour, differing from arsenikglas both in greater transparency and in the deeper yellow of its powder. When melted in a glass tube it shows with transmitted light a beautiful ruby colour, and has a phosphorescent appearance, which is also observed in the fusion of realgar and red arsenikglas. Herr Wöhler had the goodness to send me from the laboratory of the Academy some orpiment prepared there, which was perfectly vitreous, semi-transparent, of a hyacinth-red, and which when finely pounded yielded a citron-yellow powder. I found its specific gravity at a temperature of distilled water of 15° R. by one experiment to be 2·762, and by a second 2·761, while the specific gravity of native foliated Rauschgelb according to Karsten is 3·459. The hardness is that of calc-spar, 3·, while that of the foliated Rauschgelb is 1·5. Thus orpiment appears not only by its elementary proportions to be related to arsenious acid, but also is analogous to it in being able to assume the crystalline as well as the amorphous state; and that in this latter state it is less dense but harder than in the crystalline. Orpiment seems never to occur in nature in any but the crystalline state.

Arsenious acid takes up sulphuret of arsenic, whether amorphous or crystalline, in indefinite proportions, and thereby acquires different shades of red or yellow. This compound, which is to be looked on as a mere mixture, can be seen in the crystals of arsenious acid, which are produced by roasting arsenical ores; as I have remarked at the Ockerhütte in the Lower Harz, and at the silver furnaces of St. Andreasberg. The arsenikglas produced at Reichenstein in Silesia, is always made impure by some sulphuret of arsenic, in consequence of magnetic or iron pyrites being mixed with arsenical pyrites in that locality; and consequently it is always more or less coloured yellow. However, it passes in the trade for the white glass, and in fact becomes white as it loses its transparency, as Herr Seidensticker has observed. A yellow arsenikglas is made purposely for commerce* by subliming powdered arsenic with a little sulphur. The mineral, described by me† under the name of powdery sulphuret of arsenic (schlackiger Rauschgelb), which occurs in the upper parts of the Katharina Neufang mine at St. Andreasberg, as a secondary production, has by later observations been proved to be a similar combination of arsenious acid with arsenical pyrites, and must therefore in future be placed with arsenikglas. I have since met with a similar product formed from roasting the ores at the St. Andreasberg silver-mines.

[J. C. M.]

The QUADERSANDSTEIN- *or* CHALK-FORMATION *of* GERMANY (Das Quadersandsteingebirge oder Kreidegebirge in Deutschland). By HANNS BRUNO GEINITZ. Freiberg, 1849–1850. 8vo, pp. 292, with 12 lithographic plates.

THE first of the two sections into which this work is divided treats of the stratigraphical conditions of the Cretaceous or Quadersandstein-formation in Germany. On account of the absence of the true Chalk throughout Germany,—or its presence only as a subordinate member of the group of marly and calcareous rocks, separating the Upper and the Lower Quadersandstein,—the author considers that the term Chalk-formation [Kreidegebirge] should, as far as Germany is concerned, wholly give place to that of Free-stone-formation [Quadersandsteingebirge, or rather Quadergebirge (p. 281)]. This is described as comprising in general all the series of arenaceous, marly,

* Karsten's Syst. of Metallurgy, iv. s. 574.

† Nordd. Beiträge zur Berg und Hüttenkunde, iv. s. 84.

and calcareous rocks younger than the Oolitic or Jurassic and Wealden formations, and older than the Molasse, Tertiary, or Brown-coal formations.

All the marly beds interstratified in the Quadersandstein are here termed *Quadermergel*, whilst *Greensand*, *Chalk-flags* [*Plänerkalk*], *Marl-flags* [*Plänermergel*], *Sandstone-flags* [*Plänersandstein*], *variegated Marl* [*Flammenmergel*], *Chalk Marl*, *Chalk*, and other familiar local terms, have reference only to the local condition of the strata, which although sometimes resembling one another, as the Upper and Lower Quadersandstein, or a younger and an older greensand, have frequently considerable varieties of character.

The following arrangement of the series (p. 5) obtains in Germany:

I. Upper Quadersandstein, in part with Clay-schist and Free-stone-coal [Quaderkohle].

II. Quadermergel.	1. Upper Quadermergel.	Upper White Chalk with Fire-stone, Tuff-chalk, Chalk Marl, Chlorite-chalk or Greensand, Bohemian Marl-flags of Reuss.
	2. Middle Quadermergel.	Lower White Chalk, Upper Flags or Chalk-flags, Chlorite-chalk or Greensand.
	3. Lower Quadermergel.	Lower Flags or Marl- and Sandstone-flags, also Variegated Marl, Greensand, Hippurite beds, Roemer's Hils-conglomerate of Essen.

III. Lower Quadersandstein;—its upper beds passing into the Greensand of the Lower Quadermergel;—in part with Clay-schist and Quadercoal.

IV. Hils-clay and Hils-conglomerate=Neocomian.

The above is accompanied by, and compared with the Classification of the Cretaceous formation of France, as given by M. Alcide d'Orbigny in his 'Paléontologie Française, Terrains Crétacés,' tom. ii. 1842; and is also compared with the Cretaceous series of England. The chief differences pointed out are, that the Gault or its equivalent does not appear in the German classification, and that the Upper Quadersandstein is not represented in the English and French systems.

After a notice of the works and opinions of various authors on the Cretaceous series of Germany, in its totality or in part, succeeds a detailed account of the occurrence and characters of the different members of the formation under notice, at—1. Aix-la-Chapelle, Maestricht, Liege, and Verviers, p. 13; 2. Westphalia, p. 17; 3. Hanover, p. 30; 4. The Hartz, p. 35; 5. Saxony, p. 45; 6. Bohemia, p. 60; 7. Ratisbon, p. 63; 8. Silesia, p. 64; 9. Moravia, Galicia, and Poland, p. 68; 10. Countries of the Baltic, p. 68; and 11. Denmark and Sweden, p. 72.

The subjoined Table (pp. 75, 76) affords a synoptical view of the strata of the Quadersandstein formation in the different countries of Germany.

Strata.	Aix-la-Chapelle, Maestricht, Verviers.	Westphalia.	Hanover.	The Hartz.
Upper Quader-sandstein.	Aix-la-Chapelle. Verviers.	Haltern. Hüls, near Rothenfelde.	Goslar?	Regenstein, Teufelsmauer, Gegensteine, Hinterberge, Klusberge, &c.
Upper Quadermergel.	Tuff-chalk of Maestricht. Upper white Chalk with Firestone. Chalk Marl without Firestone. Greensand or Chlorite-chalk.	Marly Sandstone of the Baumberg near Coesfeld. Grey and yellowish Chalk-marl. Greensand.	Sudmerberg-conglomerate. Green Sandy Marl. Chalk-marl.	Sudmerberg-conglomerate, Plattenberggestein. Green Sandy Marl and Green Sandstone. Chalk-marl.
Middle Quadermergel.		Upper Flags, mostly Chalk-flags. Greensand and Greensand-conglomerate.	Chalk-flags.	Chalk-flags.
Lower Quadermergel.		Lower Flags (Marl-flags and Variegated Marl). Greensand.	Marl-flags and Variegated Marl. Greensand.	Marl-flags and Variegated Marl. Greensand.
Lower Quader-sandstein.		In the Teutoburg Forest.	Greensand and Grey Sandstone. Freestone.	Greensand and Green Sandstone. Freestone.
Hils-clay.		Gräfinghagen in the Teutoburg Forest.	Deister, in the Hils-valley near Hildesheim, near Schandelahe in Brunswick, &c.	

Saxony.	Bohemia.	Ratisbon.	Silesia.	Countries of the Baltic.
Saxon-Switzerland, in part.	Hohe Schneeberg. Kreibitz. Gabel.		Sieben Hirten, near Kieslingswalda. Heuscheuer.	
	Conglomeratic Sandy Marl of Kreibitz. Marl-flags of Luschitz, &c.	Sandy and calcareous Marl.	Calcareous Marl and Green Sandstone of Kieslingswalda.	White Chalk with Firestone. Chalk Marl.
Chalk-flags (Upper Flags).	Chalk-flags (Upper Flags).		Chalk-flags of Oppeln.	
Marl-flags, Sandstone-flags, Variegated Marl; generally Lower Flags. Greensand. (Conglomerate beds and Hippurite beds.)	Lower Flags (Marl-flags and Sandstone-flags). Greensand. (Conglomerate beds and Hippurite beds.)	Lower Flags?	Marl-flags, Glätz.	
Greensand and Green Sandstone. Freestone, with Clay-schist and Quader-coal.	Greensand and Green Sandstone. Freestone with Clay-schist.	Green Sandstone. Freestone.	Green Sandstone of Raspenau. Freestone.	? Striped Sandstone [Tiger-sandstein] of Mecklenburg.

The second part of the work has reference to the organic remains of the German Cretaceous system, and consists of a tabular list of the fossils (pp. 84–277), synoptically arranged in zoological order, with authorities and synonyms, stratigraphical places, and localities. The localities of such of the enumerated species as occur out of Germany are also given. The list comprises 1500 species, distributed as follows:—

Reptilia		4
Chelonia	1	
Sauria	3	
Pisces		87
Cycloidei	13	
Ctenoidei	6	
Ganoidei	16	
Placoidei	52	
Crustacea		47
Decapoda	9	
Lophyropoda*	23	
Cirrhipoda	15	
Annulata		46
Serpula (including Vermicularia, &c.)	42	
? Talpina	4	
Mollusca		685
Cephalopoda	81	
Gasteropoda	159	
Conchifera	384	
Brachiopoda	61	
Radiata		93
Echinida	69	
Stellerida	9	
Crinoida	15	

Zoophyta		423
Anthozoa	26	
Bryozoa	283	
Polythalamia†	4	
Amorphozoa	110	
Plantæ		115
Algæ	12	
Lichenes	1	
Filices	14	
Hydropterides	1	
Selagines	1	
Zamieæ	4	
Fluviales	3	
Principes (Palmæ)	3	
Coniferæ	24	
Julifloræ	10	
Terebinthineæ	1	
Carpolithes	4	
Antholithes	1	
Phyllites	29 ?	
Xylolithes	7 ?	

At pages 279 *et seq.* reference is made to observations published by the author and other naturalists on the Cretaceous formation in various parts of Germany since the publication of the first part of this work. The author again dwells on the fitness of the term "Quadergebirge" in its application to this system in Germany, and concludes with some further explanations of the use of the Tabular List of Fossils, and with some remarks on the very high value that attaches itself to the oryctographical works of Prof. Bronn (Index Palæontolog.) and M. A. d'Orbigny (Paléont. Française), to which all writers treating of such a subject as the present must be necessarily greatly indebted.

The plates attached to the volume illustrate the stratification of the Quader-formation, and forty-four fossils, of which the following have not been previously figured:—

Podocratus Dülmensis, *Becks.*
Serpula tubæformis, *Geinitz.*
Ammonites Neptuni, *Gein.*
—— Orbignyanus, *Gein.*

* [Represented by the *Cytheridæ*. The ten species grouped by the author's friend Dr. Reuss under *Cypridina* (p. 98) belong to *Cythere* and *Cythereis*.—Trans.]

† [Four only of the most common species of this group (*Foraminifera*) are here enumerated; the reader being referred to other works for an account of these minute fossils, so abundant nearly everywhere in the Cretaceous series.—Trans.]

Hamites trinodosus, *Gein.*
Turrilites Essensis, *Gein.*
Aptychus.
Scaphites quadrispinosus, *Gein.*
Strombus pyriformis, *Kner.*
—— arachnoides, *Müller.*
Acmæa Plauensis, *Gein.*
Rostellaria emarginulata, *Gein.*
Cerithium Bircki, *Gein.*
Thetis undulata, *Gein.*
Venus Goldfussi, *Gein.*
Lyonsia Germari, *Giebel.*
Mytilus arcaceus, *Gein.*
Mactra porrecta, *Gein.*
Anomia semiglobosa, *Gein.*
Chama Plauensis, *Gein.*
Lima interstriata, *Gein.*
Spongia Ottoi, *Gein.*

[T. R. J.]

On the Coal-formation *of the* Province *of* Leon. By Prof. Hausmann.

[Karsten u. Dechen's Archiv für Mineral. u. s. w. 1850, vol. xxiii. p. 761.]

It is matter of congratulation that the mineral treasures in which Spain abounds, many of which have been up to this time neglected, are by degrees being brought to light and made available for the enriching the country. As the art of mining has improved of late years in Spain, so also has the knowledge of its geological constitution progressed; whereby, independently of scientific considerations, many unexpected and solid advantages will arise to that country.

The great wealth that Spain possesses in her numerous coal-fields has but lately forced itself on observation. The existence of coal in the Asturias was long known; but the raising it in that province is only beginning to be general. It remained unnoticed until a still later period, that in the neighbouring province of Leon, south of the high mountain-chain which divides it from Asturia, an extensive coal-formation existed, with an inexhaustible store of iron-ore in its vicinity. In the year 1845, a company was formed under the name of the Palentina-Leonesa, for raising and putting to use these subterranean treasures. The geological investigation of the strata and direction of the works is entirely committed to Mr. Pratt.

The district in the province of Leon which is occupied by the coal-measures is divided in a north and south direction by the Esla, a tributary of the Duero, which takes its rise in the Cantabrian mountain-chain. The coal-measures, which rise at the utmost to the height of 400 varas (about 1000 Paris feet) above that river, have their greatest extension in an east and west direction, stretching along the right bank of the Esla, from Fuentes on the eastern extremity to Sabero, Saelices, Ollero, Sotillo, Llama, Veneros, and Las Bodas on the west. The greatest breadth of the coal-measures is in their centre, from whence to each extremity they taper away to the form of a wedge. Moreover, the northern and southern limits are somewhat irregular, presenting many indentations and projections. Both to the north and south the coal is hemmed in by lofty transition rocks. On their southern declivity the chalk almost uninterruptedly reposes, which in its westward extension surrounds the transition rocks, and to the north covers a considerable space between the transition and carboniferous systems. Besides these, plutonic masses (though not of considerable importance) occur on both sides of the Esla within the district of the transition formations on the north. At the base of some parts of the southern transition range, conglomerates and nagelflue occur extensively.

The principal beds of the coal-formation consist of clay-slate, black, grey, or red slaty clay, and quartzose sandstones, amongst which there is a very remarkable cellular variety. The direction of the beds is everywhere from east to west; they are sometimes vertical, and sometimes dip to the south at an angle varying from 45° to 90°. They contain abundant impressions of plants of the genera *Calamites, Sigillaria, Lepidodendron, Lycopodites,* &c. Some shells have also been noticed. The number of the coal-seams is remarkable, although workable beds are not found extending over the whole formation. They differ much, not only in thickness and persistency, but also in the constitution and goodness of the coal. The thickness of some of the seams is astonishing, amounting to 50, 60, and even 100 feet. That which is procured from the neighbourhood of the older formations is usually inferior to that which is raised at a greater distance.

The transition rocks, forming the southern limit of the coal-field, contain on their southern declivity a thick, dark band of limestone studded with nodules of white calcareous spar, which alternates with a grey or black clay-slate, occasionally containing mica, and effervescing with acids. The limestone contains no fossils; in the schist are found traces of plants. In the rest of the southern range of hills the prevailing rock is a grey, white, or sometimes red limestone, which is accompanied by a yellowish grey slaty clay, and a white, grey, or red sandstone. In these formations occur many fossil *Brachiopoda, Crinoidea,* and Corals. The strike of the beds in the southern chain is universally from east to west. The dip varies, but is usually to the south and always at a high angle. In some places a northern dip is observable, and also a fan-shaped arrangement of the strata.

These rocks, which are the prevailing ones in the southern chain of hills, compose also the greater part of the range rising to the north of the coal-formation. But here the sandstone, which to the south is little developed, becomes more important. Few fossils are found in it. The accompanying limestone is very cavernous. In some parts of the formation, for instance in the Sierra de las Cuestas, a hard sandstone occurs, which passes into compact quartzite. The limestone does not constantly accompany it, but in its place is found a dark or greenish slate-clay which does not effervesce with acids. In this rock no fossils are found. The dip and strike of these strata agree generally with those of the southern chain. The only exception is the Sierra de las Cuestas, where the strike is north-east and south-west and the dip from 40° to 45° to north-west.

From the researches of Mr. Pratt there can be no doubt that the fossiliferous transition rocks which form the limits of the coal-formation of Leon belong to the division which is styled in England the Devonian system. Whether the rocks composing the Sierra de las Cuestas be of the same age, or are to be considered as Silurian, is difficult to be determined from the imperfect state of the fossils. From the mineralogical condition of the rocks, Mr. Pratt considers the latter view not improbable.

The manner in which these highly inclined beds of coal in Leon are squeezed in between these similarly highly inclined transition rocks is most remarkable ; and reminds us of the analogous relation of the coal on the western edge of the Black Forest, between Offenburg and Lahr, to the masses of gneiss which seem to inclose it. As a superficial observation would induce one to believe that in that instance the coal was interstratified with gneiss ; so here one is inclined to believe that the coal-formation of Esla is a member of the transition rock in which it seems intercalated, did not the very different nature of the rock and the characteristic coal fossils which it contains forbid the conclusion. The arrangement of the coal strata also proves that their deposition took place when the beds of the older rock which bounds them were not in their present position, and that the upheaving of the transition rocks and of the coal was simultaneous. On the probable cause of this upheaving the district in question throws no light. If in many localities the rise of plutonic masses may with probability be appealed to as the lever which has changed the position of strata, yet in this case the manner in which these inconsiderable plutonic rocks occur (which, according to Mr. Pratt, belong to the family of Greenstones), does not entitle them to be so regarded.

An extraordinary abundance of iron-ore is found in the hills forming the northern boundary of the coal-formation, especially in that part which is clearly Devonian, and also in that which is probably of Silurian age. The iron is in the states of oxide and of hydrated peroxide, and occurs both in sandstone and in limestone. Deposits are found extending over miles of country, and have been proved to be of a thickness of 40, 60, 80, and even 100 varas. The sandstone often contains 20, 30, 40 per cent. of iron, and even more. The limestone is usually poorer, but offers great advantages as a flux for smelting the ore. Thus it appears that the country through which the Esla flows contains an inexhaustible store of iron, which can readily be made serviceable, since there is in its vicinity so extraordinary a provision of coal. Mr. Pratt is of opinion that the oxide of iron was not deposited contemporaneously with the sandstone and limestone in which it occurs, but that it has been introduced at a later period by plutonic agency ; a view which I adopt the more readily, as I had arrived at the same conclusion from the study of similar deposits of iron in Germany*.

The chalk formation which is widely distributed in many parts of Spain, appears in the vicinity of the Esla with its different members. From the researches of Mr. Pratt, granitic detritus appears to have furnished the materials of the lowest beds. They consist of sandstones and conglomerates, more or less consolidated, with a basis of kaolin. This substance sometimes occurs so pure that it is adapted

* Ueber die Bildung des Hartzgebirges. Abhand. Konigl. Gesellsch. Wissensch. zu Gött. I. S. 375, 412, 425.

for making porcelain ware: it is also sometimes coloured grey, red, or yellow, and then it resembles the variegated marls of the Keuper. Immediately on these repose beds of a coarse limestone, which alternate with ordinary sandstone. These beds contain many characteristic chalk fossils, such as *Hippurites* and other *Rudistes, Echinites,* and various univalve and bivalve shells. Hitherto *Belemnites* and *Ammonites* have not been observed.

The series of formations in this district closes with horizontally stratified masses of loose conglomerates and nagelflue. It is remarkable, that among these conglomerates, which consist principally of pebbles of hard sandstone with some of hornblende rock and of ferruginous sandstone, limestone pebbles have scarce ever been found, although that rock is so extensively developed in the neighbouring hills.

[J. C. M.]

Researches on the PHYSICAL GEOGRAPHY *of the* ALPS, *in relation to the phænomena of* GLACIERS, *to* GEOLOGY, METEOROLOGY, *and the* GEOGRAPHY OF PLANTS (Untersuchungen über die physikalische Geographie der Alpen, u. s. w.), by HERMANN SCHLAGINTWEIT *and* ADOLPH SCHLAGINTWEIT. Leipsic. Imper. 8vo. pp. 600. With 71 Woodcuts and 18 Lithographic plates and maps.

THIS work is the result of investigations carried on in the Central Alps, and in which the authors were mutually engaged for several years. It is divisible into four chief parts:—1. Researches on Glaciers; 2. Geological Researches; 3. Meteorological Researches; and 4. Researches on Botany and the Geography of Plants.

The first part gives the researches on the important physical phænomena of the great ice-masses of the glaciers in seven chapters; treating particularly of the characters and properties of ice, of the highest portion of glaciers [firn-meer], of the topography of the glaciers, their structure, movement, oscillation, and waste. In the second, geological, part, we have five chapters, on the hypsometrical determinations of the Alps, on the formation of the valleys and the form of the mountain-chains in the Alps, on the geology of the Oetz valley and the Tauern, the formation and temperature of springs, the isogeothermal lines of the Alps, and on the alteration of the surface by erosion and weathering. The third part contains five chapters on meteorological phænomena; the ranges of temperature, atmospheric pressure and winds, moisture of the atmosphere, optical phænomena of the atmosphere, and the proportion of carbonic acid contained in it. In the fourth part, relating to botanical researches, the manifold connexion of vegetation with climatal conditions is considered; and the effect of altitude in limiting vegetation, the periodic phænomena of vegetation, the influence of altitude on the thickness of the annual rings in coniferous plants, and the peculiar conditions of the vegetation of the Upper Alps, in the Upper Möll district, are comprised in four chapters.

Among the numerous points of interest offered to the geologist in the chapters above enumerated, the glaciers, their formation, motion, and effects, have a high place. The memoir* on the ***Physical Characters of Ice*** by M. Hermann Schlagintweit (pp. 1–25) shows that:—1. in their crystalline structure, glacier- and water-ice, under the alternate influence of heat and cold, resolve themselves into quite identical forms:—2. the air-bubbles enclosed in the ice especially participate in the formation of the crystals, and exert an influence on the form of all free surfaces:—3. the distinctly crystalline formation reaches, with the exception of the blue bands, a maximum depth of 3 metres; infiltration, however, in irregularly distributed canals and capillary chinks penetrates still deeper:—4. the air enclosed in the white ice amounts, on an average, to 6 per cent. of the whole volume of the mass:—5. the water of thawing ice absorbs air to saturation:—6. the air absorbed by the water is richer in oxygen than the atmosphere, whilst that freed from the melting ice (the portion not absorbed) is poorer in that respect:—7. the blue colour of the depths in snow, glaciers, and ice does not arise from the reflection of the firmament above, but is the peculiar colour of water in a fixed condition; in the mean it is identical with a mixture of 74·9 per cent. of Kremser-white [white-lead], 24·3 per cent. cobalt, and 0·8 per cent. of burnt ochre; being, therefore, always lighter than the blue of the atmosphere in the zenith for mid-latitudes:—8. ice exhibits throughout the properties of a hard and even a dry body; and the interstitial moveability [verschiebbarkeit] of the mass, recognized in a glacier from its structure and motion, appears to arise from the fine splintering of the ice, caused by the pressure of enormous masses and their friction against the underlying rock.

The conclusions arrived at by M. Hermann Schlagintweit in the second chapter (pp. 26–47) in regard to the *Regions of granular snow* [Firn-regionen], and from his researches on snow, granular snow [Firn, or Névé], the passage of "firn" into ice, &c., are:—1. the extent of the field or sea of granular snow [firn-meer] is in general greater than that of the glacier belonging to it:—2. the altitude of the lowest places where "firn" is met with in the Alps sometimes does not exceed 2500 feet (French); but its existence is limited also by great elevation, since it becomes converted into the more icy masses [summit-ice, or Hoch-eis] at the height of more than 11,000 feet [French]:—3. the snow always becomes the more crystalline, and at the same time the more difficult to thaw, the older it is:—4. the region of the dust-snow avalanches [Staublawinen] commences above the limits of the forests, and continues downwards only in some cases to the "montane region":—5. the marking of the "firn-meer" by snow-disks [Schnee-rädchen] is only superficial, but it shows that even slightly inclined firn-seas are composed of much smaller basins:—6. the "firn" or *névé* is generally laminated; an annual layer is from 0·75 to 1 metre in depth:—7. with few exceptions, there are no glaciers on limestone; the most essential conditions for the formation of glaciers are wide basins and an underlying rock impenetrable to water.

* Originally communicated to Poggendorf's Annal. Physik u. Chem.

From the consideration of the general characters of ice and the different forms of the important snow and "firn" beds that constitute the earliest conditions for the formation of glaciers, we are next led to the subject of the *Topography of Glaciers proper.* The glaciers of the Alps are mostly assembled in extensive groups in the neighbourhood of the most considerable elevations. According to their extent and the regularity of their forms they have been divided into the first or second order of glaciers, or primary and secondary; there is, however, a natural series of intermediate degrees. Those glacier groups that lie on the declivities beside a larger one, constituting glaciers of the second order, as well as forming the sources of the larger glacier, have been also termed lateral glaciers. The glaciers of the first order, on account of their extent and of the greater scale on which they exhibit all the peculiar phænomena of glaciers, are more particularly adapted for special examination. MM. Schlagintweit have, therefore, for the most part confined themselves to a full topographical survey of such of the larger glaciers, as those of Pasterze, and the Oetz valley; giving only occasional details of the phænomena of the lateral glaciers, particularly those of the Oetz valley, as Vernagt, Hintereis, &c. In the third chapter (pp. 48–76) the authors proceed to explain the details of the two elaborate charts of the above-mentioned larger glaciers, accompanying the volume, and the instruments used in making their observations, and to treat of the general extent of glaciers. The measurements of the Pasterze and of the Oetz-thal glaciers follow, with descriptions of their characters and external forms, illustrated with coloured lithographic sketches and numerous woodcuts, their sources, and moraines, and observations on single and compound glaciers, the origin of rock- and firn-moraines, &c. The results arrived at are:—1. the formation of glaciers is a very general phænomenon in great mountains, and is not only brought about by certain conditions of temperature and atmospheric moisture, but also by the peculiar formation of the valleys:—2. the least mean inclination of a glacier is 3°; for glaciers of the first order 5° to 7° is the inclination from their lower to their upper extremity, including their "firn-meer":—3. in an alpine valley occupied by a glacier, the following conditions obtain: the glacier proper—hard ice; the widely-extended "firn-meer"—granular snow; both are slightly inclined, and are intimately connected together. The sides of the surrounding mountains are covered with summit-ice and summit-snow [Hocheis and Hörnerschnee, forms peculiar to very great elevations], which are really separated from the "firn-meer" by deep circular crevasses ("Bergschrunde" and "Rimayes"):—4. every larger glacier has several sources, the separations of which are marked by superficial lines of stones (stone-moraines), or by extended deposits of masses of "firn"-ice. In chapter iv. (pp. 77–101) M. H. Schlagintweit describes the *Intimate Structure of Glaciers,* noticing the arrangement of the lines and bands on the surface and in the interior, also the dirt-bands, and the crevasses and ravines in the ice; and in the fifth chapter (pp. 104–124) he enters upon the subject of the *Motion of Glaciers,* describing his method of observation, and giving tabular views of the rate of motion of the Pasterze, Hintereis, and Vernagt glaciers, with notices of the alterations of velocity ; influence of temperature and effect of the weather ; relative velocities in a diagonal and straight line ; lateral movement ; annual movement ; motion of secondary glaciers and of "firn"-masses ; and with remarks on the causes of the motion of glaciers, on the "sliding" theory * ; the theory of "infiltration" or "dilatation" † ; the plasticity of glaciers ; and the interstitial moveability [verschiebbarkeit] of large masses of ice. It results from these observations, that :—1. in all glaciers the centre moves faster than the edges :—2. in the most regularly formed glaciers the rate of motion near the end is less than in the higher parts ; but irregularities of the valley-bottom, depressions, or greater width of troughs, have considerable influence on the alterations of the velocity :—3. the maximum rate of motion occurs in the first summer months ; the velocity in autumn in all glaciers is next to that of the mid-year :—4. a motion of 20–40 centimetres in twenty-four hours takes place locally in all extensive glaciers ; the absolute maximum hitherto obtained (by Prof. Forbes in the Glacier des Bois) amounts to 132 centim. a day :—5. the direction of the progressive movement usually agrees very nearly with the direction of the length of the glacier, yet also, from local conditions, lateral deviations either towards the side or the centre may take place :—6. the smaller (and all secondary) glaciers move more slowly than the larger ones, since the influence of the friction becomes more sensible, if the thickness of the ice be diminished :—7. the phænomena of glacier-motion appear to be connected with the moveability of the integral parts [verschiebbarkeit] of the ice, and this arises from the fine splintering of the mass in consequence of its dryness, the enormous pressure, and the friction of the underlying rock-surface. The rate of progress becomes essentially altered by the degree of the inclination of the underlying surface and by the vertical height of the ice, to both of which conditions the retarding influence of the friction is more or less due :—8. heat or considerable atmospheric precipitations hasten the motion, since, by the infiltration of the thaw- or rain-water into the ice-cavities, the absolute weight of the glacier is increased :—9. the rate of progressive movement is subject to considerable retardation from the friction of the ice on the supporting surface ; the base, however, of the glacier is not usually ice-bound.

Chapter vi.‡ (pp. 125–146) treats of the "*Oscillation*" *of Glaciers*, that is, the alterations and fluctuations in the absolute bulk of the glaciers,—1. dependent on fluctuations of temperature,—2. arising from accumulations of snow and the formation of moraines,—3. owing to the irregularity of the valley-bottoms, causing irregular rates of progress in individual glaciers. The *Wasting of Glaciers* is noticed in the seventh chapter (pp. 147–159), and the conclusions arrived at from researches on the distribution and quantity of the water, the terminal cavities of glaciers, the influence of superficial thawing, the measure of the waste, and the repair of the waste, are :—1. the mass of ice

* Saussure. † Charpentier.

‡ This and the following chapter are also by M. Hermann Schlagintweit.

becomes considerably diminished by thawing in the summer months; and the glacier-streams are fed in the winter by the continual supply from the gradual emptying of the canals and cavities in the ice:—2. the currents of air at the exits of the streams are the principal cause of the greater terminal cavities of the glaciers; their formation is favoured by the presence of a second, contrary aperture:—3. small bodies strewed singly over the surface favour the wasting away, but heaped up together in greater masses they hinder it, causing thereby a considerable increase of bulk in their neighbourhood:—4. the yearly amount of waste is in a great part repaired by the motion of the glacier, combined with its specific inclination; at the same time local accumulations, arising from unequal movement, appear to have considerable influence in this respect.

The geological division of the work commences with a chapter on *Hypsometric Observations* on the Alps* (pp. 163–197), written by MM. Schlagintweit conjointly. Their method of determination and the several stations for corresponding observations are first noticed, and the authors who have established previous determinations are enumerated. They then proceed to explain the elaborate Table of Altitudes that succeeds. This Table comprises 191 determinations in topographical arrangement, from which we extract some of the most important.

Numbers of the Table.		Altitude. Metres.	Altitude. Paris feet.
I. Northern limestone Alps.			
1.	Munich	518·77	1597·0
54.	Lavatschjoch	2084·4	6416·8
II. Central Alps. Tauern.			
70.	"Firn-meer" of the Pasterze glacier on the Todtenlöcher	3358·9	10340·2
83.	Johannishütte (where MM. Schlagintweit resided some months)	2462·6	7581·1
92.	Heiligenblut	1300·8	4004·4
103.	Salmshöhe	2671·1	8222·8
104.	Salmshütte	2729·8	8403·6
105.	Firn-line on the Leitergletscher	2813·1	8660·4
106.	Hohenwarte	3187·7	9813·1
107.	Adlersruhe	3388·8	10432·3
108.	Grossglockner, First Peak †	3926·8	12088·4
109.	———, Second Peak	3949·5	12158·2
116.	Summit of the Racher	3365·9	10361·6
117.	Summit of the Wasserradkopf	3190·6	9822·2
III. Central Alps. The Oetz Valley Group.			
134.	Vent	1881·3	5791·4
143.	Gurl	1788·0	5504·2
149.	Similaun	3617·2	11135·4
150.	Wildspitze	3732·0	11489·1
151.	Vernagt glacier, the lowest part of the	2100·0	6464·8

* Determined partly by means of a siphon barometer, and partly by a hypsometer (thermo-barometer).

† Of the method of reckoning used by the authors in determining heights, an example (that of the Grossglockner) is given at page 166. The notices of the Grossglockner and the neighbouring heights were originally communicated to Haidinger's Jahrbuch d. d. K. K. Geologischen Reichsanstalt, 1850, p. 125.

Numbers of the Table.		Altitude. Metres.		Paris feet.
IV. Pass between the Eisack and Oetz Valleys.				
170.	Jaufenhaus	1969·9	....	6064·2
177.	Timbls	2527·9	....	7782·6
V. Southern Declivities.				
185.	Sources of the Drau	1363·6	....	4197·8
190.	Mühlbach	753·0	....	2318·2

The above is accompanied by an appendix on the Grossglockner Peaks. Some remarks upon, and a tabulated view of, the altitudes of twenty-eight of the most important of the Alpine summits conclude this chapter.

Chapter ix. pp. 198–221, by M. Adolph Schlagintweit, on the *Formation of Valleys and the Form of the Mountain-chains of the Alps,* succeeds. In following out our special researches, says the author, on the above-mentioned subjects, it has always been our endeavour to derive therefrom some clue to the causes of the external forms of the valleys and mountains. These researches, therefore, were of twofold importance, both in a geological point of view, and with respect to other branches of physics. The temperature, vegetation, and the whole climate of a mountain-district are intimately connected therewith, whether it consists of a moderately elevated plateau, intersected by a few narrow valleys, or whether, as in the case of the Alps, it forms a series of narrow, lofty, barren summits, between which expanded valleys pass in all directions.

Valleys have been sometimes regarded as almost exclusively the effect of vehement floods and torrents; but in later times causes more complicated and connected with the stratigraphical disposition of the district have been sought for. Bouguet and Buffon believed that in most valleys the salient angles of one side corresponded with the re-entrant angles of the opposite declivity of the valley, and that all valleys have their origin in the serpentine windings of submarine currents; whilst by Pallas, Saussure, and Werner, diluvial floods, and erosion by streams and by atmospheric precipitations, were regarded as partial causes of the formation of valleys*. A local influence was also ascribed to a partial overturning and breaking up of the strata†. We must regard as erroneous the opinions, that the manifold forms of valleys can be comprised in one point of view, and that reduced, with few modifications, to one cause. One easily understands how the great valleys excavated by rivers continually eroding strata more or less soft and destructible are distinguishable from the ramifying valleys of elevated districts, which sometimes are widened out into basins and sometimes struggle through narrow ravines. In the latter, mountain masses of ever-varying profile rise on both sides many thousand feet high, whilst in the former case, above the slopes on either side we meet with nearly horizontal plateaux, but slightly raised above the valleys.

* Compare Voigt on the Formation of Valleys, 1791.
† D'Aubuisson, Traité de Géognosie, i. 1819.

In the Alps, on account of the vast mass of the mountains and the various inclinations and summits, it becomes very difficult to distinguish definite "groups" and their laws. Vegetation, also, and culture, and especially the products of weathering, obscure the original form of the district. To correct the errors arising from hence it is highly desirable to examine these valleys at intervals more or less extended, as we were enabled to do in the Tauern Alps and in the Oetz Valley.

The following researches have especial reference to the crystalline slates of the Upper Alps; we did not, however, omit to study the characteristic phænomena of the limestone Alps. And in this we have sought, by our determinations of height, by the comparison of inclinations, and by the execution of numerous profiles, to preserve assured data which may serve to give accurate and well-defined ideas of the characteristic forms. Such special researches are not without value for the general questions of geology. L. von Buch, in his well-known "Researches on Granite and Gneiss," has shown how intimately their external forms are connected with the most important processes that have taken place at their appearance on the earth's surface*.

Basin-shaped Valleys in the Alps.—In considering the characteristic forms of the Alpine valleys, much importance is to be attached to their upper extremities. Here are found peculiar basin-like cavities, which are sometimes occupied by the great Firn-meers, so essential to the existence of glaciers. Such a cavity is known as a "Mulde" (basin) or "Circus," in French *Cirque* (*de névé*); in many parts of the German Alps it is termed a "Kahr." The great bodies of ice and *névé* of the glaciers, by the covering up of slight inequalities, are well qualified to exhibit more clearly the character of these circular cavities; and only interfere with the general features so far as to cause the crests surrounding the basins to appear as naked mountains of snow and ice, whilst by closer examination they are found to be regular rock-ridges. These differ considerably in relative elevation; particularly in the hindmost, highest parts, it is often so slight, that only some grotesque, jagged pinnacles form the boundary of the basin; their base is for the most part hidden by the "firn," but their outline is more or less recognizable by means of the bedding of the "firn" and the direction of its crevasses. We have also, at rather lower altitudes, altogether similar forms not covered by snow, which may be compared with them. They are pretty clearly distinguishable from the peculiar "Kessel-" [cauldron-like] valleys, in which the lines of inclination must converge towards a central point. In the alpine basins [Mulden] there is evidently a decided inclination towards the middle in the direction of the transverse axis of the two sides; and we can trace more or less clearly a kind of central axis downward throughout the whole basin. These lines, however, together with the whole basin, have a very constant inclination towards its front entrance. In consequence of the bottom of the valley not being itself horizontal, it happens that on many maps the true form of these valleys can be scarcely recognized, since

* Abhand. d. Acad. Berlin für 1842.

the far greater slope of the walls is not sufficiently distinguished from the more gentle inclination of the basin itself. The extent of these basins is very considerable; the largest, among which the firnmeers are especially to be remarked, attain to half a square mile [German] and more.

Behind and at the sides they are enclosed by crests that surround them in the form of the segment of a circle, subject of course to much irregularity. Forwards they pass into narrow, extended valleys; the transition being either gradual, or, as in most cases, rather sudden. This narrow valley or dell [Thalenge] opens into a second open basin, having very often a breadth of 2000 to 3000 feet [French]. This continual succession of wide basins and narrow dells is very conspicuous in all the *transverse* valleys of the Alps, and have already been noticed in the valleys of the Aar, Linth, Reuss, Gastein, &c., by Saussure, L. von Buch, Escher, Studer, and others. Similar basins and circus-valleys are found in all the Alpine ranges, and in the Pyrenees, the Jura, and other mountains, and they have been noticed by Hutton and Playfair in England; their examination, therefore, must have a very general interest.

Transverse Valleys.—Fully to exemplify these phænomena the author gives a copious detailed account of the following cross-valleys:—1. The Oetzthal, with its seven basins, illustrated by a woodcut profile. This is described (p. 201) as opening into the *longitudinal* valley of the Inn, five or six miles [German] above Innspruck, by a narrow gap in the mica-schist mountains of the right bank. The great volume of the water of the Oetz alone shows that there exists an extensive valley behind this narrow cleft. The valley is composed of a series of great basins; the mountains, retreating mostly on both sides and less frequently merely on one side, enclose wide level valley-bottoms. These basins are connected in two ways; either, from a sudden subsidence or depression of the floor of the valley, a high precipice divides them, or there occurs a longer interruption by means of a ravine. The last is here more common, whilst we find the sudden depressions more developed in the Tauern Alps. 2. The Möllthal and its three basins, with a profile; and 3. The Fuschthal, with its three basins. The interesting basins of the Gastein, noticed by Von Buch, are also described (p. 207).

Longitudinal Valleys.—These long-valleys are very numerous in the Alps, and possess a similar alternation of basins and ravines as that so constant in the transverse valleys. This character however suffers certain modifications, owing to the great longitudinal extension and the less height and inclination of the former. Special examples of their most important phænomena are given in detailed descriptions of the longitudinal valleys of the Drau and Rienz, which, properly speaking, form one great valley (the Pusterthal) dividing the long chain of the crystalline slates in the Tauern Alps from the southern limestone Alps.

In the Alps it is sometimes rather difficult to define the characteristics of a longitudinal valley. It would be a great mistake to expect that these valleys must always run parallel to the chief longitudinal axis of the Alps from west to east. Under no other circumstances can we most easily perceive that the Alps are composed of a series of "groups" [Gruppen, *massifs*], and not of parallel lines. The long valleys enclose these "groups," and hence take very various directions. We find them, therefore, stretching sometimes from north to south, as the two arms of the Etsch Valley, and many others.

They are for the most part reducible to two divisions. The one set are characterized by a stronger inclination and by the alternation of great flat basins with dells, often very long and narrow, and, as in the cross-valleys, having a greater fall than that of the basins. The upper extremity of the valleys varies considerably. They may, indeed, as in the transverse valleys, take their rise on high crests; generally, however, this is not the case. These longitudinal valleys must on the whole be considered as deep depressions around the lofty mountain groups. Their upper extremities, therefore, lie for the most part deeper than those of the transverse valleys. The watershed between two long valleys is sometimes formed by a broad tract, which is enclosed by high mountains and slopes gently on two opposite sides, as is so clearly the case in the Pusterthal or on the Brenner. Sometimes, however, the two sides have very different inclinations; this happens especially with those branches that pass to the south, since the fall is here always more considerable. A fine example of this occurs in the valley of the Inn, the unusually broad plateau of which, at the Maloja Pass, descends towards the south with steep precipices.

Longitudinal valleys of the second division commence as soon as they descend to a certain height and pass as broad depressions between parallel mountain-chains, which very often belong to different geological formations. The fall then becomes trifling; the valley-bottoms are filled with beds of gravel; they are always broad, and often of great longitudinal extent, and are almost entirely free from any alteration of its character, there being a discontinuance of the basins and terrace-like sinkings. The direction of the valley also is less subject to variation. When, however, the direction is changed, ravines, or narrow passes, "Klausen," often occur which are overlooked by ancient fortifications, and have attained historic celebrity; in these cases the longitudinal valleys form the most important roads through the Alps. Such narrow passes are frequently found when the valleys leave the Alpine districts and descend towards the northern or southern plains, as in the case of the Porta Westphalica. In comparing the longitudinal and the transverse valleys, we find that the mean inclination of the former is less, both on the whole and at particular parts. The basins of the former are larger and more level, their valley-bottoms broader, and their upper ends attain by no means such an absolute altitude as those of the latter. In both, however, the mean inclination increases in the highest portion and is greatest in the ravines (intervening dells).

Secondary transverse Valleys.—Besides the long- and the cross-valleys, before-mentioned, there is an extensive series of smaller valleys. Their proportion to the former appears also to be important, and to be very various in different districts. In a district where plateaux predominate, and which is intersected only by a few valleys, these lateral valleys are but few and of a trifling extent. In the Alps, however, they are very numerous and have manifold peculiarities. A description of these, and of the *Valleys of the Limestone Alps*, succeeds.

Forms of the Mountain-chains (p. 215).—The division of the Alps into the "groups" [*massifs*], previously referred to, appears to be far more regular, both in an orographical and a geognostical point of view, than the condition of long parallel chains, which Ebel sought to trace throughout the Alps. Studer in particular has closely investigated many of these different "groups" and their combinations. He finds, particularly in the larger "groups" of the crystalline slates of the Central Alps, that two chief inclinations are distinguishable ; at their borders a series of greater mountains occur, which indicate the line of highest mean elevation. Both of these declivities are usually intersected by large transverse valleys, parallel to one another and at right angles to the line of the greatest altitude. On both of the other extremities also of the "groups" are still smaller transverse valleys. Only in a few of the "groups" does an entirely regular arrangement of the valleys occur; since frequently, sometimes the one, and sometimes the other system of cross-valleys preponderates. It is worthy of remark, that when the longitudinal axes of such "groups" extend from west to east, their slope to the south is for the most part unusually steep, whilst to the north it is but gradual. This is a repetition of the law that we found to obtain generally in the Alps; and as the northern plain clearly lies higher than the southern plain (of the Po), so also the longitudinal valleys in the south surround such "groups" at lower altitudes, than those which surround them in the north. Other features of the mountain-chains, resulting from the transverse valleys, are also described, with observations on the mean height of the passes, crests, and summits.

Mountains and Summits (p. 217).—The mountains of the Alps are not great isolated cones; they rather form portions of definite ridges, above the mean height of which some of the cones eminently rise. It is only in their neighbourhood that we can form a correct idea of this condition. Viewed from out of the deep valleys, many of the mountains appear as vast independent pyramids ; whilst, if we stand over against them on higher ground, this error is easily corrected, and we perceive that they are only portions of a long crest. Only at the extremities of a ridge are the mountains seen to stand out independently.

In the limestone ranges the forms of the mountains are somewhat different, since here the lower portions very often have steep precipices to an extent that seldom occurs in the crystalline slates. At the rear of these precipices are level spaces, above which the summits rise with only gradual ascent.

On the contours of the highest peaks, weathering and erosion by hydrometeoric operations certainly exercise considerable influence. Hence those horns and peaks rising from the narrow crests, and which particularly characterize the Central Alps. We must, however, distinguish the indentations of the ridges thus effected from the great independent peaks that often rise more than 1000 feet [French] above the surrounding parts. The latter are, in all probability, connected with the original formation of the mountain, and not resulting from the disintegrating of the atmosphere; for, if weathering and the rain have had the power to remove extensive beds of hard rock from around an isolated peak, the latter itself ought also to have entirely disappeared long since, as it offers for these operations a proportionally far greater surface than a ridge. Although the limestone mountains are in general less peaked, in comparison, yet, on account of their destructibility, and by the removal of the softer materials, gypsum and clay, they sometimes assume very curious forms. Their pinnacles (needles, teeth), owing to the continual disintegration, fall in great masses, and cause the devastation so much dreaded in their vicinity*.

In treating of the *Causes of the present forms of the Valleys and Mountain-chains*, it is stated, that both erosion by means of rivers and the disintegrating effects of the atmosphere and its precipitations, can be considered as having only subordinate influence on the formation of the Alpine districts. How (it is asked) is it possible for erosion to have effected such equal declivities, not only of the valleys, but also of the mountain ranges, and such a frequent regularity in the distribution of elevations? How could it be possible for an Alpine valley to be excavated by such means from the summit of Mont Blanc down to a depth of 3000 feet [French]?

With regard to the sudden expansion of the basins, characterizing the transverse valleys of the Alps, it is stated (p. 200), that this could not have been the result of violent outbursts of water; it not being possible for water to have collected in great masses where no dam was present to restrain it; and, if a dam had once existed, it could only have been cut through by a deep gap, and not removed entirely, without a trace being left through its whole extent. And at p. 207, in considering how far great local collections of water may have been concerned in the formation of these valleys, the author observes, that were their figure due to this form of aqueous agency, they must be regarded as cauldron-shaped cavities, that gradually became filled with débris, and now offer levelled surfaces. But this view is decidedly opposed not only by the fact of the very frequent protrusion of the underlying rock, but by the usual occurrence of the rock-surface at the slight depth of 10–12 feet [French] beneath the superficial gravel. That the basin- or trough-like forms especially, that is, the retreating of the sides of the valley on both sides, cannot have been effected by the presence of a lake, is sufficiently clear. We should otherwise confound the effect with the cause. The question, whether collections of water have generally occupied these cavities, is easily answered in most cases. We usually find here smaller gravel-beds, that by their equal distribution are decidedly shown to

* A notable example occurs in the case of the Diablerets near Bex.

have been deposited in standing waters. The inequalities of the valley-bottoms may, indeed, in many cases be sufficient cause for this; but sometimes (for example, near Lengenfeld) the form of the ravine immediately following, and the depth of the erosion of the river-channel, show that here a stopping of the water-course had taken place. At all events, this kind of aqueous operation was only subordinate, and more deeply lying causes for the forms of these cavities must be sought for in the configuration of the whole district, and in the original mode of the formation of the valleys. This is the more evident when we consider that many such basins are separated by precipitous depressions only, similar to terrace-like declivities, where there has been a perfect absence of any dams for the collection or restraint of water.

In the longitudinal valleys, on reaching which the Alpine streams have already lost much of their force, considerable beds of gravel occur (p. 212), which have been cut through by the rivers. Here again river-erosion always appears of slight importance in relation to the extent of these valleys. At the terminal gap-like openings of these valleys the eroding power of the streams is abundantly perceptible; but we can scarcely dare to attribute the cutting through of these rocks to such a cause. The signs of erosion reach at the highest to some 100 feet [French], whilst the rock-walls are many thousand feet high. It is remarked (p. 219), that the distinguished observers, L. von Buch, F. Hoffmann, O. d'Halloy, E. de Beaumont, Thurmann, B. Studer, and others, have indeed proved in different regions of the earth, that the formation of valleys is not effected by casual erosion, but is most intimately connected with the causes that gave rise to the general configuration of a district. In relation to this are especially to be regarded the manifold windings of valleys, the great change in their direction and extent; whereas in mere erosion, water would have taken the shortest and straightest passage. It frequently happens also that a valley cuts through a lofty mountain crest; whilst, on the other hand, running water would have taken an easier, and frequently already opened, course to one side. Hoffmann has proved this particularly by the well-known Porta Westphalica in the Weserthal; Omalius d'Halloy cites very similar phænomena in the course of the Rhone.

The author considers, therefore, that although running water and atmospheric influences effect important changes on the earth's surface*, yet these operations have not been sufficient to give rise to the extensive series of Alpine valleys.

The real causes of the origin of these valleys appear to lie in a series of successive elevations, associated with certain sinkings. The great basins found at the extremities of the valleys and in their wider developments, and repeated on a smaller scale on the declivities of the mountains, seem especially to point to a retreat or withdrawal

* A series of observations on erosion and weathering is given in Chapter xii. of this work.

[zurückweichen] of the masses. We ought here to observe, that the study of the valley-formation of the Alps can only be well followed out, in proportion as the general upcast of the strata approaches the perpendicular. For the strata often preserve over large tracts the same strike and dip, and are frequently cut through by a series of valleys without suffering any change. One might expect that in the great basin-like depressions the inclination of the strata would be in some degree altered. Still we must consider that the uprise or tilting of the strata is unusually steep in the Alps; a partial withdrawal, therefore, may happen without any very striking disturbance of the inclination and the succession of strata, and is far more possible than under the conditions of horizontal stratification. Sometimes only are we led to notice very striking disturbance of the stratification, particularly in the limestone Alps, and there indeed, where the greatest irregularity of the valley-bottoms has been effected by the deep depressions that even yet are occupied by the Alpine lakes. These are confined chiefly to the north and south districts, and are altogether wanting in the central parts, where crystalline slates abound and where the elevation is most regular.

Chapter x. (p. 222–234) contains M. Adolph Schlagintweit's observations on the *Geological formation of the Oetz Valley and the Tauern Range.* In speaking of the Alps generally, the author observes that crystalline slates, mica-schist, gneiss, and granite, are widely distributed, and with great regularity, throughout the Alps, stretching from the Maritime Alps, in important mountain-"groups," to Mont Blanc, and continuing on to the eastern extremity of the Alps, where they suddenly disappear beneath the tertiary formations. The constituent rocks are very various. Gneiss and mica-schist predominate, with manifold modifications; granite occurs but sparely, and mostly in isolated masses on the southern declivities of the Alps, in company with red porphyry and melaphyre. After some observations on the connection of geological formations with orographical conditions, and an enumeration of treatises on the structure of the Alps in general, and of the Oetz Valley in particular, our author proceeds to give in detail the geological constitution of the Oetz-thal "group"; premising, that the great regularity of elevation over so considerable an area, and the pretty equal distribution of the formations, are here very remarkable. In this extensive district no true granite is found. Gneiss, hornblende rock, and mica-slate are the most prevalent rocks; amongst these the last preponderates in extent, and indeed of itself composes the highest parts. Besides these, at the boundaries of the mountain-"group" there are some narrow ridges of grauwacke-like rocks of red sandstone and clay-slates; and at the northern limit towards the valley of the Inn there are tracts of limestone. The latter reach to inconsiderable heights only, and evidently belong to the great limestone ranges in the north, separated by the Inn Valley. These, together with small beds of calc-tuff, often compose low terraces, behind which the crystalline rocks rise with steep ascents. Within the district under notice occur some isolated masses of limestone of considerable interest. Masses of gneiss, hornblende rock, and mica-schist, of different widths, form some not always very distinct radiating groups, similar to such as are so frequently seen in the crystalline slates of the Western Alps. Detailed accounts of these rocks succeed; after which we have the geology of the Tauern Alps in the Upper Möll district, preceded by a list of the geological authors who have treated of this Alpine "group" (p. 228).

The Tauern are a lofty chain of crystalline rocks, forming a part of the Rhætian Alps. Especially in the north of this range the Alps exhibit a great regularity, for here there succeeds a district of tolerably developed Transition rocks, whereon the vast range of the northern limestone Alps in Salzburg and Bavaria are elevated.

The composition of this extensive "group" is somewhat various. Gneiss and mica-schists predominate; between these rocks occur great masses of chlorite slates, of hornblende rock, of calcareous schists, and of calcareous mica-schists. Granite also and isolated patches of serpentine are found at many points. The geological characters of this district follow in considerable detail.

M. Adolph Schlagintweit, in Chapter xi.* (pp. 235–273), dwells upon the *Formation of Springs and their different Temperatures*, and on the *Geothermal conditions* of different Alpine districts. He finds that;—1. In using the springs for the determination of the local temperatures of the earth, it is indispensable that, in arriving at comparable results, we direct our attention to the geological formations and local conditions, on which the nature of the origin of springs is necessarily dependent;—2. The origin of springs is not only connected with the mode of stratification, but also, and that most intimately, with the general character of the rock formation;—3. The fissures and porosity of limestone give rise to important differences in the conditions attendant on this rock and on crystalline schists. In limestone the springs are rare, copious, and, coming through this rock from other higher districts, often issue with a much lower temperature than usually found in springs flowing out at such a level;—4. The altitude at which the last springs can occur depends on the general elevation of the mountain-mass; their distance from the mean altitude of the summits and crests is greater in limestone ranges than in those of crystalline schists of equal height. In Alpine ranges of similar geological formations this distance becomes far greater when they rise far above 9000 feet (French), where, owing to the formation of steep precipices and summits, and of massive snow-beds and glaciers, the depression of the limit of springs is, comparatively, very considerable;—5. The diminution of the temperature in proportion to the altitude does not take place in an equal arithmetical or geometrical progression. In the valleys it progresses more slowly than at the declivities and summits; and *cæteris paribus* advances more rapidly at higher elevations;—6. Almost the same temperature is found at the limits of the growth of trees in the different Alpine

* Originally communicated to Poggendorf's Annal. der Physik u. Chemie.

ranges, although the altitude of this limit may itself somewhat vary. We may take 3·5° C. as the mean temperature. Immediately above the limit of arboreal growth we remark the most sudden diminution of the ground-temperature, and the most marked differences between the various springs;—7. The springs in valleys are, at equal heights, warmer than those on the declivities and summits, and this is strikingly perceptible in the higher regions. In like manner, owing to the greater radiation from isolated rock-masses, a remarkable depression of the ground-temperature takes place in the limestone Alps on the free declivities towards the north;—8. The minimum temperature of the highest springs in the Alps appears to be 0·8° C.;—9. The height of the mountain-ranges has considerable influence on the ground-temperature. We find at equal altitudes above the sea-level the warmer springs where the mean elevation is greater; the isogeothermal lines are thereby subjected to curvatures analogous to those of the lines of elevation in the district. These curvatures are shown in a diagram representing a section of the Alps. The numerical results of the numerous observations (given in a tabulated form at pp. 269–273), made with reference to the temperature of the Alpine springs and the isogeothermal conditions of these mountains, are expressed in the accompanying table (see opposite page).

The Changes effected on the earth's surface by Erosion and Weathering are considered by M. Adolph Schlagintweit, in the twelfth chapter (pp. 274–316). The Hydrographical conditions of the Alps are first insisted upon. The mass and annual distribution of the Alpine waters is noticed, also the determinations of the quantity of water flowing from glaciers, illustrated by a table. The temperatures of the Alpine lakes, springs, brooks, and rivers, the rapidity of flowing water, with a table, and the powers of suspension and solution exercised by the waters of the Alps, also accompanied by tables, are copiously treated of. With regard to the quantity of matter suspended in water, there is considerable variation in different seasons of the year, and the quantity is always considerably increased by heavy rains and falls of snow. It is important to notice the great quantity of matter suspended by glacier-streams. This is occasioned by the water, produced by the thawing of the surface, having no definite channel at the bottom of the glacier, and forming a great number of little streams that deposit a quantity of finely triturated rock-substance between the ice and the underlying surface. By the friction of this sand and the ice on the floor beneath, fresh detrited material is always being produced for the brooks.

According to Dollfuss the water of the Aar near its exit from the glacier contains 142 grammes of suspended matter in a cubic metre.

Besides detrital matter held in suspension, water in every instance contains certain constituents that have been dissolved by it. These are very various, both quantitatively and qualitatively, in the different rivers, and are connected with the general geognostical conditions of the different districts. The glaciers in high regions are of course far poorer in soluble matters than the Rhine and Aar. The substance most abundantly held in solution is carbonate of lime. A quantita-

Centigrade.	Limestone Alps.	Tauern.	Jaufen and Timbls.	Southern Declivities of the Alps.	Centigrade.
10°	Does not occur	In this "group" the point of our lowest observation was only 2800 feet. We therefore found no springs of more than 7°.	The lowest point of our observation here was 4000 feet.	2200 Eisack-valley, Franzensfeste. 2389 Somewhat to the south.	10°
9	1540 Munich	....	....	3000 Ollang........	9
	1660 (Unger).				
8	2150 Krün Isar-thal	....	....	3350 Ollang, as far as the Springs of the Drau.	8
	2540 (Unger). 2580 (Unger).				
7	2710........	2900 Möll-valley........	....	3650........	7
		3400 Fusch-valley.			
6	3050 Benedictenwand	4990 Briccius .... 4990 Kasereck.	....	3950 Between Ollang and the Drau-springs.	6
	3150 Hinterau-thal.				
5	4100 Benedictenwand	5800 Gössnitz-mine	4400 Gasteig	4290 Sources of the Drau	5
	4100 (Unger).				
4	4690 Isar........	6180 Gössnitz	5850 Jaufen........	4600 Sources of the Drau	4
3·5	4970 (Unger) .... 5700 Isar-valley	6800 ? Trog. 6500 Petersbrunn	6160 Jaufen Pass	....	3·5
3	6400 Isar-valley	7580 Johannis-springs .... 8000 Salmshütte.	6470 Timbls	....	3
2	....	8180 Hochthor	7170 Timbls	....	2
1	7450 Dachstein	8780 Goldzeche	....	....	1

tive examination of the waters of two alpine streams, made by M. Adolph Schlagintweit, is here given.

	1. The Möll at Heiligenblut. 37800 grammes of the water evaporated.	2. The Oetz at Vent. 29000 grammes of the water evaporated.
Carbonate of lime	0·3182	0·13044
Carbonate of magnesia	0·1334	0·00144
Silica	0·2719	0·25170
Chloride of potassium, Chloride of sodium	0·0330	0·01256
Oxide of iron	0·0363	0·37728
Manganese	0·1221	traces.
Argilla	traces.	traces.
Sulphates	traces.	—
Sand in suspension	0·0733	0·24888
	0·9882	1·02230

Although both of these rivers rise in the crystalline slate range, and resemble each other in the mass of the substances held in solution, yet the above analyses show important differences in the individual constituents. This is particularly the case with the carbonate of lime and carbonate of magnesia; the larger proportion of these in analysis No. 1, is due to the general distribution of carbonate of lime in all the rocks of the Upper Möll district, the composition and stratigraphical conditions of which are referred to in Chapter x.; whilst in the Oetz Valley only a few, quite isolated limestone masses occur. On the other hand, the greater proportion of oxide of iron is present in analysis No. 2; and this is always an important product of weathering. The greater proportion of calcareous matter in the Möll-district is of much interest with respect to the series of observations on Alpine vegetation, given by the author in a subsequent chapter of this work.

The history of the hydrographical phænomena of the Alps is succeeded by observations on Erosion, having reference to the present effects of rivers as eroding agents, and their relation to the formation of valleys in general; the sudden emptying of large reservoirs of water; notices of the course of the great flood (from the bursting of the Vernagt Lake) in the year 1848, with a table, showing the remarkable differences between the time required for the passage through the valley of the great bulk of the flood-water from place to place, and the usual rate of the river-water passing the same places; the influence of valley-basins on the course of great bodies of water (as seen in the table above referred to); the transport of blocks and shingles; and the collecting of the water of the Alpine lakes.

The subject of Weathering, or the mechanical disintegration and chemical decomposition of rocks by means of the atmosphere and its precipitations, succeeds, and demands notices of the physical properties of the earth and its composition, of the nature and properties of humus, and of the influence of vegetation on the formation of the earth; of the influence of glaciers on the destruction of rocky materials, the formation of sand, the transport of shingle, land- and mountain-slips, and the movement of great masses of débris.

The results arrived at from the study of these and other numerous, allied and subordinate subjects, connected with aqueous and atmospheric erosive agencies, appear to be :—1. The influence of the masses of "firn" and glaciers on the Alpine streams is not confined to the increase, but extends also to the various distribution of the water :—2. At a certain depth all of the larger lakes have nearly constant temperatures, connected with the maximum density of the water: the vertical distance of this stratum from the surface varies according to the mass of the water, the form of the lake-basin, and the season of the year :—3. The velocity of the mountain streams in eomparison with the rivers of the plains, is not in the same mass greater than their inclination, while their mass is considerably less :—4. A maximum velocity in the regular course of many rivers in transverse valleys is frequently between 7 and 11 Paris feet per second. Their velocity, however, is at other places so considerable, that they have always force sufficient to move small shingle :—5. The quantity of matter held in suspension in glacier-brooks and all Alpine streams is usually very great, and exceedingly increases their eroding power :—6. By erosive action the bed of a river may be very deeply excavated in the hard rock: such channels reach their utmost development in the more inclined ravines; they remain, hovever, confined to the valley-bottom, and have no important influence on the formation of the ravine itself:—7. The sudden evacuation of vast reservoirs of water participates very considerably in the phænomena of erosion and transport of rocks. Owing to the velocity and power of these floods, it results that the volume of rushing water is far surpassed by the mass of rocky material washed down and deposited about at different places :—8. The formation of earthy detrital matter [Erdkrume] by mechanical disintegration and chemical decomposition of rocks, proceeds rapidly at the highest summits. Its accumulation, however, and the covering up of neighbouring flat areas, are prevented by the steep declivities and the isolated situation of such points :—9. Vegetation is always highly essential for the fixing of earthy matter on the inclined sides of mountains; hence, at great heights, and in the absence of the growth of grass, the occurrence of humus, even on slightly inclined spots, is but very occasional and isolated :—10. In the Alps, particularly in the case of the crystalline slate rocks, the composition of the earth and its physical properties are very favourable to vegetation. Its proportion of humus is very considerable, even at great altitudes :—11. The glaciers not only aid in producing superficial changes by the transport of their moraine-masses, but also by giving rise to an immense quantity of fine sand, which can usually be carried far away by the rivers :—and lastly, 12. That the loosening of great masses of rock by the weather and water cause vast land- and mountain-slips; and the streams traversing the bottoms of the longitudinal valleys, owing to these fan-shaped, wide-spread masses of rubbish, are subject to frequent and considerable variations in their course.

In concluding this notice, we must mention that in the succeeding chapters, forming the 3rd and 4th Divisions of the work, several points closely connected with geognosy occur; especially on the comparison of the isothermal lines of the air with those of the earth, in Chap. xiii., and on the connexion of vegetation with geological conditions, in Chap. xxi. [T. R. J.]

On Aptychus. By Leopold von Buch.

[Leonhard u. Bronn's Neues Jahrb. f. Miner. u. s. w. 1850, 2 H. p. 244–245; and Berlin. Monats-Ber. 1849, pp. 365–370.]

In a lecture given before the Society of the Friends of Natural History at Berlin, February 1849, Ewald has shown, that in the *Scaphites binodosus*, Rœm., from the upper chalk of Haldem in Westphalia, an *Aptychus* occurs, maintaining a certain position in the cavity of the fossil, so that its medial line seems to be uniformly directed under the dorsal line of the Scaphite (and consequently under the siphon, which in the *Ammoneæ* generally extends somewhat into the cavity), its broad end towards the mouth, and its convex side towards the back of Scaphite. Subsequent to the Meeting of the Natural Philosophers at Ratisbon, September 1849, some of the geologists went to Pappenheim and Aichstedt, where they found in the collections of HH. Häberlein and Rettenbercher, and that of the Duke of Leuchtenberg, some hundreds of *Ammonites* with enclosed *Aptychi*, all of which, with some exceptions, had the above-mentioned position. In perfectly preserved specimens their position was more towards the hindermost wall of the cavity than towards the mouth. Quenstedt, in his treatise on the fossil organic remains of Germany*, likewise mentioned the regular position of these bodies at the back of several *Ammonites*, but did not perceive the true direction of the two ends. He has, however, explained that *Aptychus* possesses more of a bone-like than of a shell-like texture, being composed of small tubes; that it possesses a shelly coating over the inward, concave side only, and upon this side there are incremental stripes, for which the folds, that certain groups of *Aptychi* have on their outside, must not be mistaken. The folded species are pointed at their hindermost end, but the smooth ones are round, and for the most part peculiar to the *macrocephali*, and particularly to *Am. inflatus*, so plentiful in the Upper Jura†.

Burmeister has communicated the following opinion to the author respecting the position of *Aptychus* as parts of the *Ammoneæ*. Most of the *Cephalopoda* possess upon the back a calcareous plate, which in the *Sepiæ* is large, elliptical, and porous, and has upon one side a firmer horn-like covering, which may be compared to the epidermis of molluscs; in the *Loligineæ*, on the other hand, it is long and narrow, and composed of two symmetrical, wedge-shaped halves. Apparently

* Petrefactenkunde Deutschlands, i. 306 *et seq.*

† Comp. Herm. v. Meyer Verh. der Leopold. Acad. xv. t. 58; Quenstedt, t. 22. fig. *a*.

similar to these two groups of Sepia-plates [Schulpen] are the two groups of *Aptychus*. In the living *Nautilus*, the outer circumference of the shell corresponds with the abdominal side of the animal, but its inner wall, lying close upon the former whorls, and protected by them, corresponds with the back of the animal. Such also was doubtlessly the case with the *Ammonites*, whose ventral side, not being protected, was exposed to injury when the animal protruded itself from out of its chamber. On this ventral side were the branchiæ, directly beneath the mantle. If the mantle were torn, the gills were exposed, and not only was the respiration endangered, but the animal's power of motion was also interfered with, because, as the *Ammonites* swam by the forcing out of the water used in respiration, the animal with a torn branchial sac was no longer able to direct this stream in a certain direction, but was obliged to allow it to flow off in all directions. If, then, we suppose these *Aptychus*-shells, which were capable of falling or clapping together, were lying in the abdominal portion of the mantle over the gills, then the latter were protected. The motion of the mantle, by its opening and shutting during the act of respiration, did not only allow, but even enabled the *Aptychus* to open and to close itself again; nor was there any hindrance to the animal's withdrawing itself into its shell. If the soft parts of the Ammonite at death fell out of the shell, the *Aptychus* also fell out with it. Each species of Ammonite must consequently have had its peculiar *Aptychus*.

As there exists also a third group of naked Cephalopods that are destitute of internal plates; so there might possibly have existed a third group of *Ammoneæ* without these internal bodies; a circumstance, perhaps, explanatory of the fact of our finding so many *Ammonites* in which no trace of *Aptychus* is present.

[T. R. J.]

On a Gypsum Bed *containing* Infusoria. By Prof. Ehrenberg.

[Monats-Bericht Akad. Wiss. Berlin, 1849, p. 193–195; and Leonhard u. Bronn's N. Jahrb. f. Min. 1850, 4 H. p. 491.]

Infusoria have not hitherto been discovered in gypsum. A specimen of white gypsum,—brought by H. v. Tschichatschef, of Petersburg, from the country between Kepène and Hamsi-Hadje, in Phrygia,—formed of lenticular, densely crowded crystals, 1‴–3‴ in size, which are imbedded in a white cement of a loose texture and effervescing with acids,—was found to contain a very great proportion of particularly large and beautiful siliceous *Infusoria*. The geological relations of this rock will be detailed in the account of H. v. Tschichatschef's Travels. Microscopic analysis gives 45 determinable forms; of which 38 are *Polygastrica*, 6 *Phytolitharia*, and 1 *Entomostracon* (fragment of valve). From the perfect absence of true marine species, the presence of the siliceous parts of phanerogamic land-plants, and the occurrence of *Pinnularia Rhenana*, characteristic of the Brown-coal-formation near Rott in the Siebengebirge, the author considers that this gypsum is of freshwater origin, and probably of the tertiary or Brown-coal age. *Eunotia longicornis* and *E. Phrygia* occur here as very abundant and peculiar forms; the former is already remarkable on account of its occurrence in the *passat-staube*; whilst the latter is a new species. *Amphora paradoxa* and *Discoplea Phrygia* are other peculiar new forms. *Fragilaria paradoxa* of the Jordan is present here also.

[T. R. J.]

The Quicksilver Mine *at* Almada *in* Spain. By M. Willkomm.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1850, 4 H. p. 497; and Bergwerksfreund, 1849, xiii. p. 72 *et seq.*]

These mining works were known to the Romans. A long, tunnel-like gallery, the Socabon del Castillo, lined throughout with freestone, roomy enough to admit of carts with two horses abreast, and furnished on both sides with granite foot-ways, passes from the flat valley at the southern foot of the ridge, on which Almada is built, into the mine: the whole town is undermined. From this tunnel many other passages are cut in the clay-slate, which is the matrix of the ore, one of which opens into the Boveda de Santa Clara, a dome-shaped hall, 51′ high and 42′ broad. Here formerly stood a horse-winch for the removal of the ore. The workings reach a depth of 1140′. The Cinnabar Vein, with a strike east and west, and a nearly perpendicular dip of from 60° to 70°, has an almost fabulous bulk. In the first storey, of which the mine has nine, the vein is 18′ strong, in the lowest it is 60′. The spectacle of this colossal vein of ore at the working places is gorgeous, from the dark-red colour of the Cinnabar, which appears sometimes earthy, sometimes in dense masses, and sometimes even finely crystallized. Dispersed through it are calc-spar druses, and at many places small holes and clefts filled with pure quicksilver. [T. R. J.]

On the Agreement of Pygopterus lucius *with* Archegosaurus Dechenii. By G. Jäger.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1850, 3 H. p. 380, and Abhandl. Akad. Wissensch. München, 1850, v. pp. 877–886, pl. 26.]

The *Pygopterus lucius*, Agassiz *, from the Coal-formation of Saarbrück, depended for its determination on a single cranium with teeth, in the Stuttgard Museum. The author, having received from H. v. Alberti a quite similar, but somewhat larger specimen, from the same locality, is enabled to show that these crania do not belong to any Fish, but to a Reptile, and indeed to the genus *Archegosaurus*, and very probably to the species *A. Dechenii*, Goldfuss.

[T. R. J.]

* Poissons Fossiles, I. p. xxxvi, II. i. p. 10, ii. p. 78 & 162.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Geology *of the* Vicinity *of* Trieste.
By Friedrich Kaiser.

[Haidinger's Berichte über die Mittheilungen v. Freund. d. Wissensch. in Wien, vol. v. p. 267.]

The results of two years' residence in the neighbourhood of Trieste are here offered, rather to serve as a basis for directing future inquiries than as pretending to be a complete picture of its geology. It is still a question for anxious investigation, to ascertain the relations of the limestones of the Alps and the Carpathians with that great sandstone formation which passes under the various names of the Vienna, or the Carpathian sandstone, or Macigno, according to the country it is found in, and the identity of which, though probable, has only lately been established: and when a series of observations not yet completed shall be published, it is hoped that they will throw some light on this inquiry.

In the neighbourhood of Trieste three formations are distinguishable. Nanos and the greater part of the Karst mountains are loaded with *Hippurites*, some of the specimens being very large and well-preserved, which fossils refer these rocks with every probability to the upper chalk. Large blocks derived from the wreck of this hippurite formation, which also contains abundance of *Terebratulæ* and Corals, are sought after for economic purposes, and supply Trieste with an admirable building material.

In this formation occur those circular-shaped valleys [Kesselthäler] with ravines and gullies 100 feet deep, in which the torrents that flow into them are lost, to be again thrown up to the surface, as is the case with the stream called the Timavo at S. Giovanni near Duino, and at other spots along the coast, as well as from the sea-bottom near S. Croce. These complicated fissures have been little examined, although the right understanding them, particularly that through which the Recca flows, would be most desirable for Trieste, which is constantly liable to suffer from want of water.

H. von Morlot's excellent treatise on the geological relations of Istria contains much desirable information on that head, as well as on the probable origin of these cavities; and as a confirmation of the theory he has proposed, it should be recorded, that a piece of pisiform iron-ore has been discovered near Trebich, in the wall of a perpendicular cleft, where it was protected from the access of air.

On this hippurite limestone reposes another limestone formation, consisting of a number of parallel beds of no great thickness, the principal fossils in which are various *Foraminifera*, of which the most remarkable belong to the genus *Nummulites*. This nummulite limestone, which, like the hippurite limestone, is covered with a scanty vegetation, affords ample matter for speculation. In the neighbourhood of Trieste it forms only a narrow band in the Karst mountains, and its beds dip conformably to the main dip of the range, at an angle of about 40° to the sea. To this there is one exception. Near the village of Contovello a road was commenced some years ago, and afterwards abandoned; but a new one has since been completed leading from Trieste to the plateau of the Karst: the view of the surrounding landscape from this spot is very beautiful, which is partly due to the beds of nummulitic limestone, which here are not only vertical, but for some distance along the sea-shore form a mural precipice above 100 feet high, overhanging the macigno. With this single exception, the nummulite beds range with the dip mentioned, forming a narrow zone between the hippurite limestone and the macigno from S. Croce to the defile of Bolliunz, near the summit of the escarpment of the Karst. It is to be observed, that near the junction with the hippurite rock, the *Foraminifera* in the nummulite limestone are almost of microscopic minuteness; and it is in the upper beds that the forms become larger, the number of species increased, and the number of individuals incredibly great. The elegant forms of *Alveolina longa*, *A. subpyrenaica*, of *Melonites*, and of other species probably not hitherto described, are found in great abundance. As the beds approach the macigno, it is clearly observable that species of larger dimensions and of flatter proportions are introduced. Circular valleys, similar to those in the hippurite limestone, occur also in the nummulitic, as well as cavities between the beds; but neither so well developed as in the hippurite rock.

I have described in a former memoir * the limits of the nummulite limestone and the macigno; it is therefore only necessary for me to refer my readers to that paper, and to add that the results contained in it are perfectly in accordance with those obtained at a later period from more extended observations.

The macigno, which forms all the country immediately around Trieste, can best be studied in its vicinity, and is highly interesting from the much-contested question, whether it be the equivalent of the Vienna and Carpathian sandstones, which it so closely resembles in a mineralogical point of view. Though covered in many places by a luxurious vegetation, yet the new roads which have been cut to Opchina and to Fiume, the numerous stone quarries, and an abrupt sea-coast, afford many opportunities for observing this formation.

Wherever it is observed in the vicinity of Trieste, near its junction with the limestone, its lowest member is a thinly cleaving, greyish-blue marl. The locality at Contovello mentioned above, where the beds of limestone for a short space are vertical, is an exception, and not an unimportant one. The circumstance of the prevalence of

* Haidinger's Berichte, vol. iv. p. 158.

aluminous matter in these beds,—that they contain exclusively nothing but remains of Plants, and only contain *Nummulites* and other animal remains where they alternate with the limestones, as at Rojano,—serve to identify these beds, and to prove them to be the lowest member of the macigno in this quarter. Upon it repose innumerable beds of sandstone and slate-marl, varying in thickness from a line to several feet: here and there iron pyrites and oxide of iron, and delicate dendritic markings are seen; and over these, heaps of fragments of plants in a highly carbonized condition and not recognizable.

The beds on their under side almost everywhere are marked with protuberances and raised lines, as so frequently occurs on the Vienna sandstone. These sandy concretions even affect the partings of marl, and even sometimes penetrate to the surface of the sandstone beneath. One may almost persuade himself that they are the tracks of marine annelids which they must have excavated in the soft slime, and which have been subsequently filled up with sand.

The sandstone beds are most developed in the neighbourhood of the limestone, that is to say in their lower division, which is better seen at the tops of the hills than in the valleys; for which reason the best quarries are those of the Opchinaberg. The same is proved by the borings for two Artesian wells, one of which has been put down in the court of the town hospital, but has not yet been pushed to the depth at which a sufficient supply of water is expected. The Macigno beds near the limestone do not display so many displacements, foldings, and bendings as those at a greater distance, which are usually very thin, and so remarkable in their convolutions as to attract the attention of casual passengers. Thus on the coast, between S. Bartolomeo and the Grignano hills, a great anticlinal fold of the whole mass can be observed, causing the beds which on the heights for some toises above the sea dip towards the sea, to be suddenly bent over and dip landward.

But the most remarkable circumstance about the macigno formation is, that in several spots it contains beds of nummulitic limestone, which are conformably interstratified with the macigno. This appears to be a repetition of what has been* previously mentioned to occur at the junction of the macigno and nummulitic limestone, but which in this instance occurs at a greater distance from the limestone. Thus some way up the Opchinaberg, in a cart-track near the old Opchina road, there may be seen, between beds of macigno, a bed about an inch thick, full of small *Nummulites*, entirely calcareous, and cemented together by oxide of iron, which soon crumbles to pieces under atmospheric influence.

On the new Opchina road, about half an hour's walk from Trieste, two pretty thick bands of limestone, not far apart, are seen to be interstratified with macigno. The lower one is broken across and bent completely back upon itself: the upper one is also broken across, but the broken ends are only a little thrust one over the other. These limestone bands in their lower part are loaded with *Nummu-*

* *Loc. cit.*

lites, and a *Pecten* has also been found in them. They are of a much sandier nature than the true nummulitic limestones of the Karst, and are of a dark colour, probably from oxide of iron. It was noticed above that on the lower surfaces of the beds of macigno, protuberances occur which impress the clayey beds below them; and by attending to this indication I satisfied myself that not only the beds of limestone but the whole system was doubled up on itself*.

At one point the upper bed of limestone was broken into several pieces; yet the macigno immediately above the fragments was not broken, but merely bent. Further on, the same bed is seen to be broken in several parts, which, as in the former case, have been thrust one against the other; after this it bends upward and is no more seen.

Similar phænomena may be seen on the coast at St. Andrea, by following the beautiful promenade along the sea, which exhibits these beds very highly inclined, though but a few toises high. Here a pretty thick limestone band is seen in the macigno, the upper part of it being of an arenaceous character and containing vegetable remains (*Fuci*); whilst its lower part here also contains numberless *Foraminifera*, principally small *Nummulites*, which sometimes form protuberances on the under surface of the limestone similar to the sandy concretions on that of the macigno.

[The author gives a section which exhibits the macigno with the included band of limestone bent into two synclinal and two anticlinal folds.]

The surfaces of the cracks in the rock are covered with beautiful rhombohedral crystals of calcspar, which is well seen at the spot last indicated on the Opchina road. A remarkable circumstance which is distinctly seen is this, that the upheaving force which has caused the breaking of the limestone has only bent the macigno; clearly indicating, that at the time when these masses were crushed together, the limestone must have already become rigid, whilst the macigno must still have been soft and pasty; while it is equally clear that the macigno since that elevation has undergone no other considerable movement, otherwise the crown of the arch, which is not of hard materials, must have cracked, of which there is not the slightest trace.

Relying on this as proved, we may consider the presence of Nummulites on the under surface of the limestones and in the macigno as their natural position, without supposing an inversion of the beds or a thrusting of them one over the other†.

The same limestone, or a very similar one, is seen in a low hill at the Bay of Servola, where it is perpendicular as well as the beds which contain it.

Similar relations, but on a far larger scale than at St. Andrea, and attended with greater confusion, are seen at the south-west extremity of the peninsula of Servola. Beds of sandstone, about three feet thick, which compose the hill, are first seen bending downwards, and

* [This is illustrated by a diagram.—Transl.]
† Comp. H. von Morlot's Memoir on Istria, p. 25.

again further on at the promontory with a reversed dip. Several abrupt rocks are seen here exposed to the force of the waves, which are merely the wrecks of similar arches formed of alternations of limestone and marly beds: it is true that a complete section of one of these bands is not visible as at St. Andrea; but it is to be inferred that they have existed from the convergence of the beds and their prevailing strike. Here also the beds of the macigno are not fractured, any more than the sandstone, which is sometimes pretty thick. Three of these anticlinal axes converge, so as to resemble three inverted cones whose apices all point to the same centre. These arched beds in their upper part are of a more sandy nature, resembling the usual macigno, but they soon become purely calcareous and swarm with *Nummulites*, some of the species being as large as those at Rojano on the declivity of the Karst. I have found them $1\frac{3}{4}$ inch in diameter. They are also very abundant in a bed of clay which immediately underlies the limestone.

It is very striking to observe the passage of the sandy beds into limestones, since at the time of the upheaval these latter could not have acquired their present consistency; otherwise they must either have resisted the pressure or been fractured. Together with the *Nummulites* other marine remains are found here, for instance *Echinites* (*Spatangus*?), Corals, and a *Pecten*.

At the other extremity of the peninsula, near the hill called S. Pantaleone, a very similar limestone appears, but with much simpler relations: the fossils are the same, but the cracks in the limestone are filled with white stalactitic incrustations which cannot have originated in the immediately overlying beds of clay and sandstone.

The geological relations of the rocks on the shore of the Gulf of Pirano to Capo d'Istria are still simpler than those of the opposite shore of Trieste, but not less deserving of remark. For these two miles along the shore the macigno forms horizontal strata of uniform thickness, which compared to the Trieste beds exhibit very slight disturbances. Near Pirano the coast forms almost a right angle, which enables one to see that the beds dip about 11° to the southward. Here there is a very remarkable yellow limestone, about three feet thick and very hard, interstratified between thin beds of marl and sandstone, and most exactly conformable to their bedding, at the same time without producing the slightest change in either the under- or over-lying stratum, which is not the case in any one of the situations hitherto described. The upper part of this bed, which is the more arenaceous, contains the same *Fuci* as the macigno: in the middle and lower part they are wanting: but for the thickness of an inch the lower part consists entirely of *Nummulites*, which in size, shape, and even in colour, closely resemble lentils. This rock has a singular appearance, in consequence of certain fissures which run in a transverse direction to the bedding, and for the upper and lower third are even perpendicular to it. The course of this rock, after it has sunk below the road, can still be traced out to sea by a line of projecting reefs.

The strike of this bed can be readily followed along the coast to

Isola: to the eastward at Pirano it sinks gradually from the primitive mountains to the sea, which however it never reaches. Here and there it is broken through by abrupt ravines and covered by a luxuriant vegetation. This is remarkably the case at an old saltwork near the promontory called "Punta Ronco," at which point the range of hills, in whose escarpment the limestone is seen, turns in a landward direction. It is very deserving of attention that the limestone is invariably attended by a greyish-blue marl which forms its roof, as has been already observed of the upper beds of the nummulitic limestone in the Karst hills.

The main road from the saltwork to Isola leads from the limestone bed up a hill, which consists of macigno dipping a little to the south. On the summit the road leads for a few toises along the marl, and then again the limestone with its numerous fissures appears from under it, forming the covering of the hill, and reminding us by its poorer vegetation of the barren limestone rocks of the Karst. However, it is only necessary to descend a few paces by the foot-road to Isola, to satisfy oneself that the limestone in question is merely this single bed I have described, which here, near the chapel of S. Maria of Loretto, covers the ridge of hills for some distance.

Under it lie beds of macigno several hundred feet thick, which form the sides of a semicircular valley, on whose northern extremity stands the town of Isola, on a promontory at some height above the sea. The bottom of the valley, as well as the promontory, consist of grey hard nummulitic limestone, covered here and there with soil, the junction with the macigno being covered with detritus. However, if it be borne in mind that the beds of the nummulite limestone, like the macigno, are nearly horizontal, with a slight dip to the south—that the macigno gives no evidence of a shifting of its beds, and their original lines of deposition seem to have undergone no considerable change—if it be remembered that in the limestone not only a hot spring but also a cold spring of most unusual abundance bursts out, which becomes very muddy by continued rains, which circumstance, with great probability, connects this limestone with the cavernous limestone of Inner Istria—(in which case it is demonstrable that there is no water-bearing stratum between the Isola limestone and that of Inner Istria, such as the macigno would have proved)—if to these considerations be added, that here, as in other localities, the stratum of macigno nearest to the limestone is a greyish-blue marl, which has hitherto always been found overlying the limestone—all this being considered, it is not hazardous to affirm, in the absence of positive proofs, even without the analogy of the Opchinaberg, that these macigno beds overlie the limestone, and are a newer formation; which the abundance of *Nummulites*, now acknowledged as tertiary fossils, would alone have made probable.

Along the shore from Isola to Capo d'Istria this band of limestone again appears in the macigno, but dips occasionally beneath the sea-level. In this part it is thicker than in the previously described localities, being usually about 9 feet thick: in all other respects it is the same, so that only one spot deserves to be mentioned in the neighbourhood of Capo d'Istria where the limestone band is broken across and seems raised, while the macigno which contains it only undergoes a slight twisting of its bed.

The facts described seem to warrant the following inferences :—

1. The hippurite limestone lies under the nummulitic limestone, and the latter under the macigno.

2. A tranquil deposition took place from the formation of the nummulitic limestone to that of the macigno.

3. The macigno was deposited before the limestone was upheaved, which is distinctly proved by the lower macigno beds having undergone the same contortions as the contiguous limestone beds, as seen at Opchina.

4. At the time of the elevation of the Karst mountains the limestones were consolidated, while the macigno beds were yet soft and flexible, and accordingly were in some cases easily bent, contorted, and even thrown over, of which the best examples are on the Opchina road.

5. The macigno since it was upheaved (which must have been subsequent to the nummulitic epoch) has undergone no change of any consequence.

Nevertheless many objections have been raised against several of these conclusions; for instance, the assertion that the macigno is newer than the nummulitic limestone, even in the vicinity of Trieste: and without entering into the intricacies of the Vienna and Carpathian sandstones, it is clear that great caution is required in fixing the age of the macigno. H. von Morlot *, who examined Istria so carefully, from observations made at Pinguente, considers the macigno older than the nummulitic limestone. In the same way observations made at the valley of Bolliunz and the hill of S. Servola above the village Dollina, would lead to the conclusion that the macigno underlay the nummulitic limestone. In fact, at St. Servola, high up the hill, the macigno seems to dip under the limestone; yet on the declivity towards Ospo the limestone seems to lie lower: moreover the grotto of St. Servola, which sinks to a considerable depth, never reaches the macigno, which would have been the case if it underlay the limestone. H. von Morlot has justly observed, that a bed of blue marl lies between the nummulitic beds; but on the northern side of that same mass of limestone, which presents a deep perpendicular escarpment, a blue marl and then a mass of macigno are seen to repose most incontestably upon the limestone.

Let it suffice for the present to have indicated the doubts suggested by these intricate relations, and to indulge in a hope that they will be ere long removed.

The very remarkable rocks constituting the promontory of Grignano ought here to be noticed, which advances into the sea about a mile from Trieste in a N.W. direction. Blocks of rock of the size

* It shall be my endeavour to ascertain whether at Pinguente and other places in Istria that learned author has not lighted upon a band of Nummulites, similar to, if not identical with, that which I have described, and which unfortunately he has not seen, between Pirano and Capo d'Istria.

of a house, containing *Nummulites* of all sizes, *Terebratulæ, Echinites,* spines of *Cidarites,* &c., are found sometimes lying on the macigno; sometimes inclosed in it, in which latter case the macigno exhibits remarkable dislocations near its edge; and sometimes they appear to project out of it. From these apparently contradictory conditions we may gather, that these rocks were not formed of debris which was thrown down upon the macigno, but that they were already consolidated when they came into collision with the masses of macigno which were still soft. If the problem were not attended by mechanical difficulties, one might assume that these blocks had travelled from the high chain of limestone to the north; but until more accurate inquiries have thrown light on that unknown epoch, these doubts cannot be solved.

[J. C. M.]

On the Comparison *of the* German Jura Formation *with those of* France *and* England. By Oscar Fraas.

[Leonhard u. Bronn's Neues Jahrbuch f. Min. u. s. w. 1850, 2 H. p. 138–185.]

The older the formations are, the easier is their comparison with each other in the different districts of the earth's surface. Because the further we trace the genesis of the earth in its earlier times, the more uniform do we find the soil and climate with its inhabitants; so that species exist in the Transition rocks which are identical in Asia, Europe, and America. In the newer formations this phænomenon never re-occurs, because the younger the earth becomes, the more manifold are the conditions of soil and climate. In the Jurassic period, then, soil and climate have already become so different, that it is only by a comparison of the same stratum in different countries that we can arrive at a decision with respect to its identification.

The dissimilarity of the bottom of the sea, and that of the bays and gulfs, exerted an influence upon the formation of strata too great to admit of an extensive deposit appearing everywhere the same. Besides, there were the conditions of the shores, the propinquity or distance of the land, the depth of the sea, the mouths of rivers, and local influences in general, by which the same stratum must, in different parts, have been differently formed. The younger the Jurassic strata are, consequently the more apparent become the different local conditions of a stratum. Whilst the deposits forming the "black Jurassic" rocks are pretty similar in different countries, they already differ in a greater degree in the "brown Jurassic" series, and in the "white Jurassic" rocks the characters are so manifold, that it is impossible to prove the identity of certain strata. The *Arietes-* and *Gryphææ*-limestones are found everywhere, from Swabia to England; they commence the Jura-formation. But those which form the last member of the series, the Portland limestones, are only found in Dorsetshire; identically similar rocks and fossils appearing nowhere else, inasmuch as the Portland group is the result of conditions which are wanting in other localities. Portland limestone is neither found in Swabia nor in Switzerland; but there are synchronous deposits which may be paralleled with it. In general, therefore, in speaking of a comparison of the Jurassic rocks, we have less to say of strata of the same character than of the same time, and we are confined to the synchronism of the formation. Therefore the task of comparing the Jurassic rocks of different localities infers the comparison of synchronous deposits with each other, and the consideration of their local differences and conditions, as well as the species of animals and plants contained in them. The result of this examination will be a restoration of the form of the sea at the Jurassic epoch, its extension and boundaries, together with its inhabitants. In order to accomplish this, the observation of the local influences upon the formation of the strata is of the greatest importance. We have therefore to observe:—

1. *The influence of the shore;—its condition, and its proximity or distance* [*to the place where deposition is going on*].—The Lias sandstone, for instance, which is strongly developed in Swabia in the lower "black Jurassic" series, is never found after leaving the Jura, until we reach northern England, in the form in which it occurs with us. There it reappears, because the causes of its development are the same as in Swabia. The Lias sandstone is nothing else than the deposition of the Lias together with the Keuper,—the transition of the one formation into the other. The yellow upper Keuper sandstone, which is itself merely a continued deposit of Keuper sandstone, is the first condition and factor of the Lias sandstone. The circumstance of sandstone being formed, generally speaking, proves the presence of a shore consisting of sandstone; which, loosened in the water, gave rise to new precipitations in another form. The sandstone shore in Swabia was the Black Forest, in the East of France the Vosges. The further we go away from these sandstone shores, the more destitute is the Lias of the sandstone formations. Thus also were formed similar strata of the lower "black Jurassic" formation, which appears as an alternation of lime- and sand-stone in proximity to the shore; and far from the shore, in the depths of the sea, as a pure calcareous deposit. Normandy is a normal type for pure pelagic precipitations,—formations far from the shore in the open sea. Here sandstone is not at all known in the Jurassic series. The thickness of the strata is quite insignificant, because accumulations are not possible in the open sea. In this Lias, saurians, fish-teeth, and breccia (which prove the proximity of a shore) are either not found at all, or are exceedingly rare. At Fontaine Etoupefour (Départ. Calvados) the whole Lias is from 6′ to 8′ thick, but even in this thickness all the divisions of the Lias are represented in miniature;—a proof that the thickness also of the strata, and not their materials only, depend upon the proximity or distance of the shore.

2. *The depth or shallowness of the sea exercises an influence upon the conditions of its inhabitants, and consequently upon the species of the imbedded organic remains.*—We seek in vain in the Swabian Lias for corals, which are especially evidence of shallow seas: Calvados is very rich in them. In Burgundy, the Jura, and Normandy, whole banks

and reefs of corals are met with in the "brown Jurassic" rocks: in Swabia they are rare. With the depth of the sea the size of the shells is also related;—the *Terebratulæ* and *Spiriferi* of the Lias are twice as large in Calvados as in Swabia; the *Ammonites* of the *ornati*-clay grow here to such a gigantic size, that one who has only seen the Swabian specimens can scarcely recognize them again. We need not point out that the materials also of the deposits, and their greater or less thickness are connected with this point.

3. *The quality of the water.*—Apart from the many springs and currents in the sea which carry with them lime, quartz, and other matters, to be contributed to the formation of rocks, there are especially two great causes which sometimes conjointly, and sometimes in succession, are continually at work, contemporaneously forming a stratum with varying characters at different places. These important factors are the salt-water and the river-water. The former is particularly adapted to form limestone beds, consisting of the, often scarcely distinguishable, remnants of molluscs and zoophytes. Remains of a few plants and bones, scattered about without order, bivalves with their separated shells, and remains of other molluscs, lie buried, or rolled up in heaps, more or less water-worn. But where river-water unites itself with the sea, there the deposits consist of clay, argillaceous limestones, and sandstones, according to the nature of the soil through which the rivers take their course. Regular strata here exist. Remains of plants and wood, *Saurii* and *Sepiæ* are common. The molluscs lie frequently grouped into families, in nests together. Fixed corals are entirely wanting. Constant Prévost has ventured to explain from these two causes alone the differences of all the formations. Among the Jurassic strata he points out as of marine formation the *Arietes*- and *Gryphææ*-beds, the oolitic limestones of the "brown Jurassic" series, the Great Oolite, the *macrocephali*-bed, the coral-rag, and Portland limestone; and as fluvio-marine formation, the Lias sandstone, the "black Jurassic" clays and marls, the sandstones and clays of the "brown Jurassic" series, the Oxford clay*, and the Kimmeridge clay. At all events we here see how one stratum is variously formed in different localities, according to the local influence of the sea-water, either by itself or in connection with river-water.

If we regard the different Jura-formations from this point of view, we see also the impossibility of having common names for the different strata. Most of the names are only correct as local names, and have only a special meaning; but as soon as these special names are applied to other similar strata they confuse and puzzle us. What confusion have the appellations Bradford clay, Oxford clay, Kimmeridge clay, and particularly the Portland, already caused in the German Jurassic formation! The Germans have indeed a right to be proud of their Jura-series, for in no other country have these rocks found such clear stratigraphical development. Why do they still give to many a genuine German stratum an English name which

* [See also Mr. R. N. Mantell on the Oolite of Wilts, Quart. Journ. Geol. Soc. vol. vi. p. 315.—Transl.]

by its application becomes false? I am certain that there exists no Bradford clay either in Germany or in France,—that grey clay of the S. of England at the top of the Great Oolite with its abundance of fine *Apiocrinites intermedius, elongatus,* and *Parkinsoni,* and with its herds of well-preserved *Terebratulæ, Aviculæ, Myæ,* &c. In Swabia we have nothing similar; the Bradford clays are a peculiar local formation of the south of England. So it is with "Kimmeridge" and "Portland,"—they are and remain local names, which cannot be applied to the deposits of other localities.

The names of the strata according to their fossils are of greater value. In so far as the typical shells in the different strata are the same, by comparison we soon arrive at some degree of clearness: but here also we meet with peculiar difficulties; because those organisms which are leading in one country, and which give the name to the stratum, disappear from this stratum in other countries, appearing again as typical characters in a higher or a lower stratum. This is, for instance, the case with *Ammonites Parkinsoni*: in Swabia it is the type for the stratum above *A. coronatus* and beneath *A. macrocephalus*; in France and England it is the typical shell for the lower Oolite, and is followed by *A. Murchisonæ, A. Humphriesianus,* and *A. coronatus.* In the same manner, we can neither use for France or England such appellations, so well adapted to the German Jura-rocks, as *Amaltheus*-bed, *opalinus*-clays, *Jurensis*-marls, *Scyphiæ*-limestones, and others, because the fossils referred to appear there either not at all, or very rarely, and other kinds of fossils are found which characterize the stratum better. A synonymic examination of the different stratum-names is therefore necessary for the comparison of the Jurassic rocks.

A. Black Jura. Lias.

The foundation of the Lias is not always the Keuper. Almost as frequently it is an older rock, of the secondary or primary age. But sandstone formations in Lias are always connected with the development of the Keuper series. The close connection of the Lias sandstone and that of the whole black-Jura-rocks with the Keuper cannot at all be denied. Hence some French geologists* regard the Keuper sandstones as liassic beds inferior to the "Jura," because the Keuper in that part appears much too insignificant to be regarded as a formation of itself. In Swabia, where the Keuper and "Jura" Formations are so distinctly separated, this is regarded as an important error. But the slight development of the French Keuper is an excuse for those geologists who, from its insignificance, added it to the "Jura." Even the whole Trias to the west of Lorraine begins to disappear.

The boundary of the Lias consequently varies considerably. In Germany it is everywhere the Keuper,—sometimes the upper sandstones, sometimes the red marls. Likewise so in Switzerland and in the Jura, although nothing certain can be observed here on account of its confusion at most places. Towards Burgundy, however, the

* See Thirria, Notice sur le Jura de la Haute-Saône.

Keuper gradually diminishes in thickness. It certainly once more makes its appearance, leaning against the sandstones of Central France, in Cher-Department, and at the Canal du Centre; but far from such sandstone beds it is reduced to a minimum; an arkose rock takes its place at last (Avallon), and it now disappears entirely, so that the Lias rests upon granite. The Keuper and Trias, therefore, disappear entirely from the Bourbonnais to England. In Calvados and Sarthe-Department, the boundary-conditions are very interesting; here the blue *Arietes*-limestones lie immediately upon the red Transition sandstones with Trilobites, facts which may be observed between Caen and Alençon at many places in the quarries near the road. The line of distinction between these two closely adjacent formations is so absolute, that one can knock off hand-specimens consisting half of Trilobite sandstone, half of blue limestone with Lias fossils. A remarkable appearance seen here is, that pebbles of the sandstone are inclosed in the *Arietes*-limestones, and even in the younger calcareous marls of the middle Lias lying above the *Arietes*-beds: and, on the other hand, the Lias mud has penetrated into the clefts and cracks of the sandstone, and there become hardened.

The extent and divisions of the Lias are determined by its boundaries. Sometimes the Lias forms only a small strip, closely bordering the steep sides of the mountains, and sometimes it extends into plains; the different strata of the under, middle, and upper Lias are often arranged one upon another regularly in a terrace-like form; and often the terraces appear as if they were drawn away from each other, the different strata lying near each other at the same height. Here must the Swabian Jura-rocks be taken as the normal type, for in no other country are the bedding of the strata and the terrace formation better marked. In Swabia sometimes the Lias has a plain-like extension, according to the development of the Keuper boundary (as between Eyach and Schlichem, Tübingen and Stuttgart, Rems and Kocher, Ellwangen and Öffingen); sometimes it presents only narrow strips (as at the Wutach, Upper Neckar, between Hechingen and Reutlingen); but everywhere we soon arrive at a correct result, because the separate strata are mostly distinguishable in their outlines and the gradations of the ground. But this is quite different as soon as we pass the Rhine, because from thence the terrace-like arrangement of the beds one upon another disappears. In the Jura, or in the lower land of Berne, where the "black Jura" is developed, there is no great extension in width; there are mostly slips or rents where the different strata show themselves in profile in a mass of about 100′; at the bottom of the rents the fossils of all the strata lie mixed together. The position of the strata one by the side of another is also the case in Burgundy, the Cher-Department, and the Calvados. In passing, for instance, from Avallon to Vassy, where the celebrated "Roman cement" is manufactured from the *Posidonomyæ*-schists, or from Arcy to Avallon, all the Lias series is found exposed near the roads which traverse a plain, the distinctive limits of the strata having been removed; and the observer passes imperceptibly from stratum to stratum.

In the neighbourhood of Caen, where no rocky land-marks of the formations are visible, like those in Swabia where every one can perceive them, all the members of the Jurassic series are of trifling thickness, and lie side by side, covered, moreover, mostly with alluvium. Close to Caen lies the Great Oolite (Oolite de Caen). If we go a few thousand steps further upon the road to Alençon, we come to the red Transition rocks with Trilobites ; if we turn from thence half a league towards the north, we are at Fontaine Etoupefour, the celebrated Lias quarries ; the uniform Great Oolite then again appears, under which, in the sections made by narrow valleys, the inferior Oolite or the Lias is seen exposed. In short, it is very difficult, and almost impossible, for one who is not acquainted with the normal Lias, to find his way in the "black Jura" of France. At the same time, the relative altitudes cause confusion, because in France the reverse condition exists in comparison with Swabia, the elevation of the "white Jura" being less than that of the "black ;" the Marne, Seine, Yonne, Loire, Cher, Indre, &c., all of which flow westward, descend from the Lias to the "brown Jura," and thence to the "white ;" whilst in the German "Jura" the rivers flow from the heights of the "white Jura" through the "brown" and the "black."

As before said, there is no country in which the members of the "black Jura" are so distinct, and where the demarcations are so sharp, as in Swabia. I place the Swabian before the French and English "Jura," in order to see at once how different are the local arrangements of the Swabian strata. I use Quenstedt's classification*, as being the best for the Jurassic system of Swabia.

I. Lower Black Jura, α. and β. (Quenstedt.)

Limestone of the Lower Lias Shale. Lias.

Lias inférieur ; Calcaire à Gryphée arquée.

Étage sinémurien (D'Orb.).

In the German Jura a difference of structure already appears in the lower Lias. We meet there with two principal formations ; both sandstone and clay being developed. Sometimes the two appear together, sometimes the one, or the other, or even both are wanting. The latter is the case in Franconia : in the valleys of the Maine, Regnitz, Wiesent, and Pegnitz the lower Lias nowhere attains to any significance, appearing only as coarse-grained, hard sandstone of a few feet in thickness. Occasionally it contains, as a sign that we are no longer in the Keuper, a *Gryphæa*, or *Ammonites Bucklandi*, or a *Thalassites*. It appears as if the Keuper, which in that district is so strongly developed, had left no room for the Lias. The blue clays with *Am. costatus*, constituting the middle Lias, often seem to lie directly upon the Keuper. In this form the Franconian Lias extends as far as the Ries, where the Swabian clay-formations commence, which often rise to 100 feet and more. If these are fully developed, then dark blue limestone beds with *Am. psilonotus* and *Thalassites* form the undermost stratum above the yellow Keuper

* Das Flözgebirge Würtembergs. Fr. Aug. Quenstedt. 8vo. Tübingen, 1843.

sandstones, and sometimes have reference to the "Bone-bed." On this are superposed alternating clays and sandstones, in which *Am. angulatus*, again accompanied by *Thalassites*, occurs, and at some favourable places numerous fine *Gasteropoda*, also *Lima, Nucula, Plagiostoma*, and others are conspicuous. In sequence to these, the first appearance of the fauna, in the blue *Arietes*-beds, occurs. The quantity of *Ammonites* of the *Arietes*-group, the hosts of *Gryphæa arcuata*, the beds of *Pentacrinites basaltiformis* are here always constant. In the second division (β) of the lower black Jura, the foregoing is succeeded by a strong development of black clays, only sparingly interrupted by insignificant limestone beds. Whilst in these limestone beds *Ammonites* of the *Arietes*-group, together with *Pholadomyæ* and *Terebratulæ*, make their appearance for the last time, there begins in the clays a new organic series, with *Am. Capricorni* and *Oxynoti*, forming a transition to the rich series of organic remains of the middle Lias. This is, however, by its light grey limestones so sharply separated from the black clays of β, that we need not here draw an artificial line of demarcation between the formations.

The principal development of sandstone is upon the four Filder-plains of Würtemberg; westwards it decreases more and more the nearer we come to the Wutach and Switzerland. In this decrease *Am. psilonotus* also participates; this form, however, according to M. Merian, has been found in Switzerland, but is there no longer the type of a geological horizon; because generally in Switzerland *A. Bucklandi* occurs immediately above the Keuper. The clays with *A. Turneri*, coated with quartz, are developed near Pratteln.

In the case of Mont-Jura, some quarries near Salins are exceedingly instructive. Here the Keuper supports a yellowish grey limestone bed, 1½ foot thick, with *Thalassites* (*Cardinia*) *concinnus, Th. securiformis*, and *Plagiostoma*; upon which rests the *Arietes*-bed with *Pentacrinites*; the lower black Jura terminating here with the dark blue Gryphite limestones. Above these are found greyish black clays, interstratified with limestone bands, clays full of *Ammonites oxynotus* and *A. bifer*, calcareous marls with *Pholadomyæ, Mactromyæ*, and *Arcomyæ* (*Corbula cardioides* and *Thalassites Listeri*), with *Ammon. raricostatus* and *Gryphæa cymbium*, but without forming a line of demarcation with regard to the middle Lias. Those greyish black clays which towards their base contain the *Oxynoti*, have still lower down *A. Taylori, A. Jamesoni*, &c.; in short they become our *numismalis*-marls. It is clear that with the French geologists the middle Lias begins with our β, as they take *Gryphæa cymbium* as the typical shell, which is found from β. throughout to γ. Respecting the geognostic conditions of Mont Jura, my friend Jules Marcou has published a valuable work in his 'Recherches Géologiques sur le Jura salinois*'; our β. forms the first section of his "Lias moyen," which he formerly called *Marnes à Gryphæa cymbium*, but now, after having seen its strong development at Balingen, he has named it *Marnes de Balingen*.

* Mém. de la Soc. Géol. de France, iii.

The inferior Lias of Burgundy is again differently modified from that of the Jura. It has, above all, more extensive limestone beds, especially the stratum of the *Thalassites.* At Semur and Beauregard the strata contain iron; and the numerous *Thalassites* are replaced by [oxide of] iron and excellently preserved. This stratum is invested with such importance in this district, that D'Orbigny denotes the whole of this division of the lower Lias as *étage sinémurien.* Besides the Thalassite beds, the clays and limestones with *Ammonites angulatus* (*A. Moreanus,* D'Orb. and *A. Boucoltianus,* D'Orb.), are also well-developed, upon which the *Arietes*-beds, having a thickness of from 10 to 12 feet, repose. Above these is an argillaceous limestone bed, of a few feet thickness, with *Am. Brookii* and "*cinctæ*" *Terebratulæ,* and with *Am. oxynotus,* which however is calcified and with a diameter of about 6–8 inches; this represents β. in Swabia. We find *Am. oxynotus* converted into quartz, with *A. bifer* and *A. raricostatus,* in the Cher-Department, near St. Amand, where Swabian conditions exist. On the other hand, things appear different in the south of France, in the Rhone district, where, according to M. Victor Thiollière*, black limestones, without the specified *Arietes* and *Gryphææ,* are found in much greater force than anywhere else, instead of the *Arietes*-beds existing in England, in the north of France, and in Germany. This formation he calls the "type mediterranéen," as in general the whole Jurassic series in the south of France presents a peculiar aspect.

Whilst the lower Lias gains in development in the south of France, it decreases towards the north. The whole section in Calvados is reduced to 1 or 2 feet, and a *Gryphæa arcuata* or an Ammonite of the *Arietes*-group becomes very rare, until in England (Lyme Regis) the full development of the strata recommences. Here again also, as in Swabia, we find the Lias sandstones (Linksfield and Brora) and *Ammonites psilonotus.*

In Swabia and England, therefore, there is a perfect development of the lower black Jurassic rocks, to which those of France are very inferior. The same relative proportions are found in the appearances of the strata: Swabia is in this respect the richest country; richer than England, which only has the preference in regard of the preservation of specimens; such as *Ammonites obtusus,* Sow., with its interior chambers elegantly filled with white calcareous spar, and the external chamber occupied with the blue limestone of the matrix. France, however, may be called poor, in spite of the many species that D'Orbigny mentions. Each country has also its peculiar organic remains; what is found in one country is either wanting entirely in another, or at least is not so abundant. If we only consider how the different families of the *Arietes* offer at different localities different species and varieties, we shall see that the genuine *Ammonites obtusus,* Sow., is peculiar to England and the Aisne-Department; *Am. Turneri,* Sow., is only found in England and Swabia; and, according to my view, the calcified *Am. Turneri* occurs but rarely in the east of France on the top of the *Arietes*-beds (compare, in D'Or-

* Bulletin de la Société Géologique: Séance du 4 Nov. 1847.

bigny, &c., the *Am. stellaris* and *Am. Scipionianus,* which are evidently in part the inner whorls, partly young specimens of *A. Brookii,* Sow.). The genuine large *Am. Bucklandi,* Sow., is found much more seldom in France than in the other two countries, whilst here *Am. bisulcatus,* Brug. (=*Am. rotiformis* and *Am. multicostatus,* Zieten), is more frequent. Of *Am. psilonotus,* Quenst., I have already said that I did not find it at all in France. Jules Marcou, however, appears to have discovered some traces of it in Mont Jura; at all events it is extremely rare. *Am. tortilis,* D'Orb., commences, with *Am. liasicus,* D'Orb., from the *Arietes*-strata, and is a variety of the same without the siphonal furrows. *Am. tortus,* D'Orb., is the true *Am. psilonotus,* and, I know for certain, has not its commencement in France. *Am. oxynotus,* Qu., commences in the middle of the German Jurassic series, and extends through Mont Jura and Burgundy as far as the Cher-Department (St. Amand), in company with *Am. bifer*; thence it disappears as far as France is concerned, and reappears in England (Gloucester). Here, however, this Ammonite is replaced by the different varieties of *Am. heterophyllus,* which become always thicker and more considerable. The accompanying *Am. bifer* becomes very fully developed, and has near the opening of the mouth a long, projecting, tongue-like process. England appears to be rich in beautiful and tolerably abundant *Hippopodium ponderosum* and the large *Avicula cygnipes*; and *Lima, Pecten,* and *Thalassites* (*Pachyodon*) are conspicuous in beauty and perfection, more than in other countries. The generally typical forms, however, in all countries are *Thalassites* and *Am. angulatus* for the lowermost beds, together with *Gryphæa arcuata* and the varieties of *Am. Bucklandi*; for the clays and limestones lying above these, *Gryphæa cymbium* and *Am. raricostatus.* The last two form the transition to the fauna of the middle Lias.

II. Middle Black Jura, γ. and δ.

Argillaceous Lias. Marlstone Series.

Lias moyen, Lias supérieur, in part. *Marnes à Bélemnites et à Gryphæa cymbium.*

Étage liasien (D'Orb.).

We have certainly already found *Gryphæa cymbium* together with *Am. raricostatus*; but, lying immediately below the *numismalis*-clays, the middle Lias must be considered as the real locality of those important shells. This appears clearer in France than in Swabia, especially at the east side of the elevated tract in Franconia, where the Jura rocks are exposed. I do not know any place exhibiting these strata better than the village of Aschach, near Amberg. It is a little retired place, entirely surrounded by post-tertiary sands; below the village, in the valley, occur the white Keuper sandstones and red clays; upon the heights lies the coarse-grained, quartoze Lias-sandstone, and above this a light-coloured limestone bed of about 2–3 feet thick remarkably rich in fossils—*Gryphæa cymbium,* of 6 inches in length and 2–3 inches in breadth, is conspicuous; and is accompanied by *Am. natrix*, *Am. capricornus*, *Am. Valdani* (4–5 inches in diameter), *Am. ibex*, *Am. centaurus*, together with a great quantity of *Terebratulæ rimosæ* and *cinctæ*, *Spiriferi*, *Plicatula*, and *Lima*. All of these are preserved with their shells, and their appearance and conditions remind us of the celebrated petrifactions at Fontaine Etoupefour, in Calvados. We are indebted to M. Sigmund von Schieder, of Amberg, for the more particular knowledge of this place. Aschach is the only known locality in Franconia where the middle Lias is developed with the Ammonites of the *numismalis*-clays. In general we are but indistinctly guided until we reach the blue clays lying at the top of it, with *Am. costatus*, which is the most important Franconian type, and everywhere serves as a sure guide at the slopes of the Danube and Maine canal, near Altdorf, Bamberg, and Banz. By means of *A. costatus* also a bed of red iron-ore, found at a not less remarkable place in Franconia, near Keilberg, close by Ratisbon, has been recognised as belonging to the middle Lias. As is well known, on the west and east of the Land-Rücken (white Jura) there occur black and brown Jura. On the east side, however, these strata cannot be traced to any extent; only at some localities the highest points protrude above the drift-sand, which covers everything between the Bavarian forest and the Land-Rücken. The Keilberg, upon the heights behind the Tegernheim Beer-house, near Ratisbon, is such an isolated projection of lias. Some years ago a mine was opened here and a very rich bed of red iron-ore discovered, lying on the great, hard, sandstone strata. This is characterized by *Am. costatus*, *Belemnites paxillosus* (*alveoli*), *Pecten æquivalvis*, *Terebratula rimosa*, *T. acuta*, *T. vicinalis*, *Spirifer rostratus*, and other species, the specimens being changed into iron-ore; whilst the sandstone lying beneath must decidedly be considered as belonging to the Keuper.

In Swabia the boundary between β. and γ. is drawn too sharp by nature to be overlooked by the geologist. The middle Lias commences with the light-grey calcareous marls and an abundance of *Ammonites* of the *Capricorni* family, together with innumerable specimens of *Terebratula numismalis*, transformed into quartz. The first section of γ. concludes with a bed of *Belemnites* and a limestone bed with *Am. Davæi*. Above it dark clays make their appearance with *Am. Amaltheus*; light-coloured calcareous marls with *Am. costatus*, *Belemnites paxillosus*, and *Plicatula spinosa*, terminating the series. The development of this formation in Swabia, as well as its organic remains, varies in many ways; often the *numismalis*-clays only are developed; the others being reduced to a minimum. So it is likewise in Switzerland, where for the most part the *numismalis*-bed alone represents the middle Lias; and on the top of the *arietes*-beds lighter-coloured, but less sandy, clays make their appearance with *Terebratula numismalis*, *T. rimosa*, *Gryphæa cymbium*, *Spirifer verrucosus*, and *Am. capricorni* and *lineati*; on the other hand, the *amaltheus*-bed is scarcely anywhere to be seen.

In Mont Jura there is, as has been already mentioned, no such line of separation as in Swabia. A series of grey clays, alternating with limestone beds, rises from the *arietes*-beds up to the *posidonomyæ*-schists; the order however of the fossils remains the same. Undermost in the clays are *Am. bifer* and *Am. oxynotus*; in the limestones *Pholadomya ambigua, Mactromya gibbosa,* and *Am. raricostatus*; further upwards succeed *Am. planicosta, Am. natrix, Am. lineatus,* silicified in the clays and calcareous in the limestone; and after these come the Belemnite-beds with *Am. Davæi.* Above this again are found *Am. Amaltheus* (*margaritatus,* d'Orb.) and *Am. costatus* (*spinatus,* Brug.) impregnated with quartz; an immense number of *Plicatula spinosa* and *Belemnites paxillosus* mark the termination; the latter, however, not in such beauty and numbers as in Swabia. This last stratum is called by the geologists of the Jura, *Marnes à Plicatules.*

In Burgundy, the *numismalis*-clays do not differ from those of Swabia; on the other hand, the *amaltheus*-clays (δ.) have a development not to be seen in the latter country. They are no longer the clays that form δ, but greyish blue limestones of considerable development, in which, together with the gigantic *Am. Amaltheus* and *Am. costatus,* occur *Gryphæa gigantea,* Goldf. (a variety of *G. cymbium*?), *Terebratula acuta, T. digona, T. lagenalis, T. vicinalis, Pecten æquivalvis, P. glaber, Pholadomyæ, Myæ,* and *Spiriferi,* in great quantity and mostly also of great size. The environs of Avallon, Vassy especially, is a normal district of this middle Lias. The *amaltheus*-limestones here form whole rocks of a greyish yellow colour, and filled with the fossils enumerated. Clays with silicified shells are entirely wanting; the bed appears only in a calcareous form, and together with the character of its organic forms, has reference evidently to deep-sea conditions. It appears that this great development of the *Amaltheus*-stratum does not exist anywhere except in Burgundy; for in the Cher-Department or the Isère it is much decreased; at the latter place it contains a great deal of iron, like our Wasseralfing limestone; *Am. Amaltheus* and *Am. heterophyllus* are frequently present in it. Further towards the south and also towards the west this stratum disappears; and it re-appears at Calvados near Bayeux, Curcy, Croisille, &c. But here the character of the formation has become very different, chiefly in reference to the organic remains, the light yellow calcareous marls of γ. containing, together with *Am. Jamesoni, Am. Davæi,* and a host of very beautiful and rare *Terebratulæ* and *Spiriferi,* a number of Corals, *Cidaris*-spines, and very rare *Gasteropoda,—Euomphalus* and *Conus.* The following are very conspicuous:—*Terebratula quadrifida, T. Deslongchampsi* (quite new, and having a general resemblance, except as regards the central perforation, to *T. diphya*), *T. lagenalis, T. vicinalis* (of a remarkable size), *Euomphalus cadomensis,* a great quantity of *Turbo, Trochus,* and *Pleurotomaria,* and towards the top, *Am. Amaltheus* and *A. spinatus,* the *Gryphæa gigantea* of Burgundy, *Pecten æquivalvis,* and *P. glaber.* The light-yellow coloured beds in which the above-mentioned fossils are found are scarcely three feet thick. Clays are here entirely wanting, but appear nevertheless at some places; for instance at Vieuxpont, where *Am. Amaltheus,* *Am. heterophyllus, Am. maculatus, Am. lineatus* (sometimes with a ventral lobe extending upwards in the wall of the chamber) well-preserved in quartz, and an abundance of *Belemnites Bruguierianus* (*paxillosus*) are to be found.

The same conditions obtain also at the other side of the Channel, and the marlstone series comprehends the same that the *Lias moyen* of the French and our β. γ. δ. contain. The *Am. oxynotus* and *Am. bifer* are geologically further removed from the *arietes*-beds than from the *numismalis*-clays, otherwise their conditions are the same as those in Swabia; only sometimes other typical shells occur, and the two fossils, *Terebratula numismalis* and *Am. Amaltheus* (*A. Stokesi*), from which the Swabian strata derive their names, are but rare. In England, *Gryphæa cymbium* and *G. gigantea* are rather characteristic of the middle Lias.

If we now compare the strata in the different countries with one another, the absence of *Gryphæa gigantea* in Swabia is remarkable. In France this shell is so abundant that it is generally taken as the typical shell for our *amaltheus*-clays. D'Orbigny names it in his 'Paléontologie Française' *G. cymbium*, whilst he sets down our German *G. cymbium*, from the Lias β, as a variety of *G. arcuata*; hence the confusion experienced by the German geologist when he reads of *G. cymbium* as accompanying *Am. margaritatus*. It must be remembered, therefore, that D'Orbigny under this name comprehends *G. gigantea* of Burgundy, distinguished especially by the concentric rings of the ventral valve, varying from an oval to the most perfectly circular form, and attaining a size of 5–6 inches. Whilst this shell, serving as a type in France and England, is wanting in Swabia, it happens on the other hand that *Terebratula numismalis* marks a sharply drawn horizon by its abundance in Swabia, Switzerland, and in the east of France; it is certainly found sometimes in Burgundy, but from hence towards the west of France and in England it is not only no longer characteristic, but is scarcely ever found in its primitive form as *T. numismalis*; instead of it *T. vicinalis* and *T. quadrifida* make their appearance. The same is the case with the *Ammonites* of the stratum; the rich series of Swabia not being found again in any other country. *Am. Jamesoni*, one of the most frequent *Ammonites* in Swabia, is rarely found in France; *Am. Regnardi*, d'Orb., an allied form, but spinose, which is found here and there in our localities, seems to take its place. On the other hand, *Am. armatus*, Sow., is peculiar to England and seldom occurs in Swabia or France; so also *Am. striatus*, Zeit. (*Henleyi, Bechei*, Sow.), which is always rare in Swabia, but is frequent in England. *Am. Amaltheus*, the most abundant Swabian Ammonite, appears less frequently further towards the west, whilst its companion *Am. costatus* appears more frequently in France and England than in Swabia. The most general Ammonite is *Am. heterophyllus*, which, however, I do not regard as being the typical shell for this bed, as it is almost always found where there are Ammonites. Even very lately Herr v. Alberti found the genuine *Am. heterophyllus* in the γ. of the "white Jura" in the Braunenberg near Wasseralfingen. Besides, it is subject to great changes of form, as is shown by D'Orbigny's *Am. Guibalianus, Am. Buvignieri, Am. Loscombi.* The form with wide umbilicus is abundant at Vieuxpont; in England it occurs mostly in Lias ε. and ζ. The δ. of Swabia has produced the finest specimens. The *Gasteropoda,* which are found in Swabia in great quantities mostly silicified and small, have their greatest development in Calvados. They certainly are the same species as those with us, but the individuals are much larger and have been better fed, so that our species of *Turbo* and *Trochus* are scarcely to be recognized again. We must also add the many new forms which have never been found in Swabia, such as *Euomphalus* or *Conus,* which, as far as I know, are elsewhere wanting in the Jura-rocks; and corals, as *Anthophyllum, Lithodendron,* &c., which bear evidence to conditions of the sea quite peculiar and different from those found elsewhere.

III. Upper Black Jura, ε. and ζ.

Upper Lias Shale. Alum Shale. Whitby Shale.

Marnes du Lias supérieur. Schistes bitumineux et Marnes à Trochus. Couche de ciment de Vassy.

Étage toarsien (D'Orb.).

The blackish grey bituminous schists or limestones with *Posidonomyæ,* sharply and distinctly separated from the middle Lias, offer in almost all countries a safe geological horizon. This Formation is very rich in the remains of Vertebrata. The British Museum is enriched with a perfect skeleton of *Ichthyosaurus platyodon* 25 feet long, with the several well-preserved *Ic. tenuirostris,* with *Teleosaurus Chapmani,* and with numerous fishes, all from these beds at Lyme Regis and Whitby. No less fortunate is Swabia, where the district of Boll, Ohmden, and Holzmaden abundantly supplies the German cabinets. The Saurians of Banz also and its environs, discovered and illustrated by Geyer and Murk, are well-known. But besides these, doubtlessly numerous other places might be found equally rich. In France one of the principal localities is Vassy near Avallon (Dep. Yonne), where the *posidonomyæ*-schists, of 12–15 feet thickness, are worked for the manufacture of cement. Remains of Saurians and Fishes are here frequently found, and also *Am. heterophyllus, Am. annulatus, Am. Deplacei,* &c. Croisilles (Dep. Calvados) is not inferior to Vassy; but the development of this formation in France is not equal to that in England and Germany. In Mont Jura and in Switzerland it cannot always be traced; it is often covered up or overturned for miles; other strata however share the same fate; nevertheless at Aargau, Basle, Solothurn, &c., it attains a considerable development. The examination of this so important formation of the Lias in different countries seems to prove, that this deposit attained its maximum development chiefly in quiet, protected bays and basins, near the mouths of rivers. Saurians particularly affect such places, the embouchures of rivers especially; and Fishes of all kinds, *Crinoidea,* and *Cephalopoda,* including *Sepiæ, Belemnites,* and the smaller *Ammonites,* would abound in so favourable a habitat. The dead animals have by the products of their decay rendered the fine mud more or less bituminous; hence the soft shaly character of the bed. With the deposition of the *posidonomyæ*-shale we must necessarily connect that of the greyish-yellow limestones superimposed on them. Although in Swabia the light-yellow calcareous marls of the *Jurensis*-strata appear to be markedly distinct from the black *posidonomyæ*-shales, the boundary-line is nevertheless erased in other countries, and, especially in a palæontological point of view, there exists no difference between the two strata. In Calvados, in Dorsetshire, and in Yorkshire there is one deposit, with the Jet Rock towards its base, shaly and bituminous; one great system of clays (in Yorkshire thirty times thicker than our *Jurensis*-clays) up to β. of the "brown Jura." Together with the saurians and fishes are already found *Am. radians, Am. Walcotti, Am. heterophyllus, Am. communis, Am. fimbriatus,* which also continue upwards through the whole mass of the clay.

Am. Jurensis, one of the most instructive typical shells of the clays of the upper Lias (ζ.), disappears in Switzerland and Alsace; occasional specimens are sometimes found in Mont Jura, but further on in Burgundy, in the west of France, and in England it is altogether wanting. *Am. lineatus opalinus* is found instead in these countries, and continues up even to the inferior Oolite. Besides this there are other *Ammonites* belonging to the family of the *lineati,* which in France and England represent the *Am. Jurensis,* as for instance *Am. cornucopiæ* and *Am. Germaini.*

Am. radians is in all countries generally characteristic of the upper Lias. It is especially interesting to trace the varieties of this Ammonite. In the interior of Swabia some varieties of this far-spread shell occur at certain places; *Am. Aalensis* appears most frequently in the neighbourhood of Aalen; there also the variety *Am. radians depressus,* very similar to *Am. psilonotus,* occurs; *Am. radians costula* belongs especially to Franconia; and both there and in the neighbourhood of Aalen *Am. radians comptus* occurs; but these species on the other hand are more rare at other places. In the environs of Balingen (and I think that this will also be found at other places by careful examination) there exist within the distance of two to three leagues, distinct varieties that change with the localities; how much more must this be the case in a distance of 400 miles! *Am. Levesquei,* D'Orb., is for the most part peculiar to Calvados. *Am. Walcotti,* which is not so prevalent in the German Lias, occurs already in great number in Burgundy, and gradually attains, in England, its greatest development.

The *Am. planulati* of the "black Jura" are in Swabia mostly crushed between the shales; they are most perfect and elegant in Calvados and in England. In Calvados we can collect, in the light-yellow-coloured calcareous marls, thousands of *Am. Hollandrei,* D'Orb. and *Am. annulatus,* Schl. *Am. annulatus* of Yorkshire is common in all cabinets; *Am. mucronatus, Am. Requienianus,* &c. of Pinperdu, near Salins, are not found in Swabia, but reappear in Franconia.

Mont Jura and the Haute-Saône possess a very peculiar Ammonite, found nowhere else, *Am. sternalis,* D'Orb., which is certainly closely allied to *Am. insignis,* but separated from it by its form and lobes. In the neighbourhood of Salins, which has become celebrated through my friend H. Marcou and Dr. Germain, it is frequently found in company with a legion of small silicified Ammonites.

Besides the *Ammonites* there are two *Belemnites, B. digitalis* and *B. acuarius,* which occur as important characteristic shells, sometimes together and sometimes singly, in the *posidonomyæ*-shales and the clays, and never appear again either above or below. The Ludwig Canal especially yields an immense quantity of these two *Belemnites* at the celebrated cutting near Rasch, and wherever the laminæ of the *posidonomyæ*-shales are broken, one of these *Belemnites* will always be found. They pass quite through France, where however *B. acuarius* becomes more frequent; and lastly, the large and slender specimens of the English *Belemnites* are well known. We must also particularly mention the *Cyathophyllum mactra,* and other small corals, which are likewise found almost everywhere in this deposit, and afford a proof that it was not formed in a deep sea, but in shallow water and, in part, not far from the shore.

The following are generally characteristic of the formation: *Am. insignis, Am. radians* with its allies, and the family of *lineati,* especially the reticulated species; also *Belemnites acuarius* and *B. digitalis.* The entire absence of *Terebratulæ* is also characteristic. Marcou calls these beds *Marnes à Trochus ou de Pinperdu.* In this mountain, near Salins, the clays of the upper Lias have great thickness, are highly inclined, and afford a beautiful profile of the different fossiliferous strata. *Trochus duplicatus, Tr. Capitaneus, Tr. Vesuntius, Cerithium tuberculatum, Nucula Hammeri, N. claviformis, N. ovalis, Arca æquivalvis,* and others are found here in great abundance. These certainly are found towards the top, but in company with *Am. mucronatus, Am. insignis,* and *Am. sternalis*; a proof that we have already here the French forms, according to which the upper Lias coincides with the *opalinus*-bed of the lower "brown Jura." In the German Jura the Lias ends with this bed ζ, and, according to all the circumstances, must be here separated from the "brown Jura." With the *opalinus*-clays there begins a distinct geological series, another terrace in the gradation of the strata; new fossils make their appearance, and the relation of α. with the next stratum β. is too great to allow of their separation. In France and England it is otherwise; here there exists one inseparable system of clays and marls, between the *posidonomyæ*-shales and the sandy limestones with *Am. Murchisonæ.* But it is quite as correct in France to reckon the clays with *Nucula Hammeri* as belonging to the Lias, as it is impossible to do so in Swabia; because our characteristic shells, *Am. opalinus* and *Trigonia navis,* are there wanting.

B. Brown Jura. Oolite.

The principal difference between the German "brown Jura" and the French is, that here the limestones, and there the clays predominate. In Swabia the "brown Jura" comprehends a much greater rock-mass than the "black;" but, nevertheless, on account of the predominance of the clays, there is only thickness without extension in width, so that it can scarcely be put down upon small maps. It is quite different in France, where the limestone beds of the Inferior Oolite, and especially of the Great Oolite, form large plains, and often have six times the development of the Lias. In the south of England the same condition exists, whilst in the northern part there is an approach to the Swabian proportion. These very opposite proportions of clay and limestone in the "brown Jura" are shown by comparison of the district near the Wutach with Burgundy.

Near Blumberg the whole "brown Jura" consists of a steep slope 300′ high; upon the summit of the mountain is "white Jura," at the foot of the rent is Lias. Almost the same happens on the upper Neckar, near Spaichingen, Aldingen, Schomberg, and at many other places in Swabia,—a rivulet, rushing down from the "white Jura," within half an hour traverses the "brown Jura." The contrary exist in Burgundy, where the clays are represented by great limestone masses extending over several miles, and forming sometimes plains, sometimes bold rocky valleys. In Lorraine, in Calvados, and in the north of England, it is Oolite that constitutes, by its wide extension, the principal part of the Jura. These different geognostic formations point back to the different local conditions of the old Jura-sea; extensive calcareous deposits being evidence of pelagic conditions; whilst clays and sandstones testify to the neighbourhood of a shore. Hence the comparison of individual strata becomes still more difficult, and as it becomes impossible to find the same bed in all countries, we must confine ourselves to the synchronism of the strata; a task the more difficult as the members of the Jura-series attain wider and wider extension.

It is moreover interesting to trace a parallel between the Lias and the "brown Jura" in the above-mentioned countries where the sandstone formation again appears in the lower "brown Jura," as well as in the lower "black Jura," in Germany and in the north of England; whilst in France and in the south of England these formations are very insignificant, if not sometimes entirely wanting. This leads us to the first division of the "brown Jura."

I. Lower Brown Jura, α. and β.

Inferior Oolite. Northampton Sandstone. Cheltenham Freestone. (Ferruginous beds.)

Grès superliasique. Oolite ferrugineuse.

Étage bajocien (D'Orb.). *Oolite inférieure,* in part.

In this bed, especially in α, the *opalinus*-clays, we have almost exclusively a German local formation. The Vosges constitute its boundary towards the west; Alsace, Swabia, and Franconia form its centre; Switzerland likewise comprises a small portion of it. These are unctuous, black clays, in which the mollusks are very well preserved, usually with the shell and a natural nacreous lustre. In general these extensive clays, sometimes above 100 feet thick, are very poor in fossils; it is only in occasional beds that an abundance of the finest shells is presented. Leopold v. Buch calls these peculiar fossils the real German mollusks. The first place, as a typical form, is occupied by the *Trigonia navis,* hitherto only found in Alsace, Swabia, and Franconia. The family of the *falciferi,* which made its appearance in the *Jurensis*-bed, is likewise represented in the German species of *Am. opalinus,* Rein. (*Am. ammonius,* Schl.), the constant companion of *Trig. navis,* which always appears and disappears with it. Together with *Am. lineati,* which in this stratum are usually reticulate (*Am. hircinus, Am. torulosus*), are also found *Belemnites compressus, B. clavatus,* and herds of *Nucula Hammeri, N. claviformis, Astarte,* and small *Gasteropoda.* As a parallel to this bed, so peculiar to the German gulf or bay, there now appears in France and England the uppermost bed of their upper Lias, in which *Am. radians,* the reticulate *lineati, Nuculæ,* and *Gasteropoda* occur; immediately above these appear the sandstones, chiefly oolitic.

The ferruginous sandstones have a very close connection with the *opalinus*-clays. They are likewise local littoral formations, which, however, extend somewhat farther than the clays. A distinct boundary between α. and β. cannot be pointed out in Swabia; fine and unctuous below, the clays become farther upwards more micaceous and sandy, until they form true sandstones alternating with clay beds. They are characterized by *Am. Murchisonæ, Am. discus, Pecten personatus, Gryphæa calceola,* and *Gervillia.* In the north-east of Swabia we find iron-ore beds in these sandstones; iron is indeed found more or less wherever they appear; and hence the rock derives its peculiar brown colour. The thickness of this formation increases in the Kocher valley to 300 feet, but decreases more and more towards the south-west; near the Wutach, where the bed once more assumes its full development, in Switzerland (Berne, Basle, Solothurn, Aargau), where the fossils are less frequent, it has less thickness and forms an alternation of arenaceous clay beds and sandstones, which towards the top pass into hard limestone beds. This is termed by the geologists of Mont Jura *Oolite ferrugineuse*; but by this is meant only the sand-beds, with *Am. Murchisonæ* and *Nautilus lineatus*; the sandy clays lying on the top of the *Jurensis*-bed (*Marnes à Trochus*) are called by them *Grès superliasique,* on the grey sandy laminæ of which remains of *Asterias* are remarkably abundant. This *Grès superliasique* is also found in Burgundy (Vassy), where, however, the arenaceous beds begin to disappear. This is completely the case at Calvados and in the south of England, where the so-called Inferior Oolite lies immediately on the top of the *radians*-beds, and contains in the harder limestones of its lower portions *Am. Murchisonæ, Am. Edouardianus,* D'Orb, *Am. Tessonianus,* D'Orb., and *Nautilus lineatus.* To the north of Bath sandstones reappear; in part, as great local formations, as at Northampton and Cheltenham (Crosshands), which are known as inferior oolite. These formations change from the coarsely oolitic character through all shades to the finest sand, sometimes brown and ferruginous, sometimes white with yellow bands (Arbury Hill). *Am. Murchisonæ* is certainly wanting, but *Pecten personatus, Clypeus sinuatus, Pholadomya obtusa,* and others are chiefly found.

Thus there re-occur here, at the beginning of the "brown Jura," conditions similar to those with which the "black Jura" commenced;

viz. those of sandstone formations in localities bordering on older sandstone mountains, such as the Peak, the Vosges, and the Black Forest. Far from such mountains, upon the open sea, these conditions were wanting, and consequently these deposits are also wanting, or are represented only by unimportant limestone beds.

II. Middle Brown Jura, γ. and δ.

Inferior Oolite. Étage bajocien (D'Orb.).

γ. *Lower Coal. Calcaire à Entroques. Calcaire lædonien. Calcaire à Polypiers.*

δ. *Oolite inférieure. Oolite de Bayeux.*

Marnes vésuliennes. Marnes à foulon.

Fuller's Earth.

Hard blue limestones with *Pecten demissus* passing upwards into brown marls, with *Myacites depressus* and spines of *Cidarites*, constitute the transition to a system of clays and calcareous marls—δ, which, sometimes of a lighter, sometimes of a darker colour, are distinguished by an abundance of fossils. *Am. coronatus, Am. Humphriesianus, Ostrea crista-galli, O. pectiniformis*, a legion of *Terebratulæ*, and *Donax Alduini*, are characteristic of this series. Above these succeed dark-coloured clays with *Belemnites giganteus*. So also in Swabia and Switzerland. In the latter district above the sandy clay beds, with *Am. Murchisonæ* and a *Gryphæa* with a large ear (which is also frequent in the south-west of Swabia), lies a red ferruginous oolite, containing the shells of δ, *Terebratulæ, Am. coronatus, Ostrea*, and *Bel. giganteus*. In Mont Jura, as well as in Swabia, this is separated into beds of hard limestones and clays, the former surpassing in bulk the superincumbent clay, contrary to what takes place in Swabia. The limestone which is very constant, and passes through the whole of Burgundy, is greyish blue, hard, and brittle, containing numerous stems and arms of *Encrinites*. Hence it derives its name, *Calcaire à entroques*; another name is *Calcaire lædonien*, from Lædo, Lons le Saunier (Dep. Mont Jura), where these limestones attain their greatest development. Above it repose thick limestones with corals, the *Calcaire à Polypiers*, which occupies a considerable tract in the east of France. These limestones, then, pass from Mont Jura, along the Vosges, over Besançon, Vesoul, and Nancy, to Metz. *Agaricia, Pavonia, Astræa, Anthophyllum, Lithodendron*, in company with *Terebratulæ, Myæ*, and spines of *Cidarites*, characterize this formation, which in many places has so great a proportion of silica, that the shells of the *Myæ* and *Terebratulæ* are well-preserved in quartz. The similarity between this and the Coral-rag is very remarkable. These coral-limestones must be looked upon as peculiarly a French formation; for its equal is nowhere to be found either in Switzerland or in Germany. I am inclined, however, to regard our blue limestones as a synchronous deposit, the lower portions of which, the real, hard, blue limestones, which are poor in fossils, answer at all events to the *Calcaire à entroques*, and the French coral-limestones might then be compared with the upper marly beds of γ, which contain, like those in France, fragments of *Myæ* and *Cidarites.* Corals can never be regarded as typical forms in different countries, for, according to climatal conditions, a bed may contain corals at one place and be destitute of them at another. Corals have even been found in Swabia in γ, in the stone-quarries at Donzdorf, at the foot of the Hohenzollern, and at other places. This occurrence of corals in the "brown Jura," which, commencing in the eastern Jura-range of France, stretches into Burgundy, and from thence into the English Inferior Oolite, is again a proof how every stratum can become a coral-rag, and how the whole *facies* of a bed may be subject to variations even under similar existing conditions. Already connected with this is the succeeding Great Oolite, so important a formation both in England and France, which is associated, above with the Forest-marble, and below with the Lædonian limestone. In these three formations is centred the whole French Jura-elevation; here are the highest summits and the greatest extensions in width; and it is only the clays that are interstratified with it, often unobserved and of insignificant thickness, that faintly remind us of the parallels in other countries.

To these limestones first succeed the calcareous marls, light grey or blue, with badly preserved fragments of *Ammonites* and *Belemnites,* but rich in *Conchifera.* I do not hesitate to regard the *Marnes vésuliennes* or Fuller's-earth as the equivalent of our δ. *Am. coronatus* and *Bel. giganteus* are certainly wanting, but the mass of the shells resemble those in Swabia. These marls are properly characterized by *Ostrea Marshii* (*crista-galli*), *O. Knorri, O. acuminata, Gervillia, Perna, Pholadomya Vezlayi, Pleuromya, Nucleolites,* and *Dysaster.* In Burgundy, where the limestones are in greater force than the clays, hard yellow limestones, termed *Oolite inférieure,* with *Am. Parkinsoni* and *Donax Alduini,* for the most part take the place of the clays; but there are generally found a few clay beds on the top, with *Gervilliæ* and *Pernæ,* which the geologists of that district call *Marnes à foulon.* These clays reappear particularly in the Département de la Sarthe, where the two last-mentioned shells, together with *Gervillia tortuosa* and *Gastrochæna,* are numerous and well-preserved.

To this also is the English formation related. The γ. is either referable to "inferior oolite," or rather it is not to be distinguished as a special bed. Still there are sandstones that pass into oolitic limestone with *Pentacrinites vulgaris, Terebratulæ,* and Corals. Above these in the south of England occur the beds of Fuller's-earth, sometimes argillaceous, sometimes arenaceous, in which *Gervillia, Perna, Pinna, Ostrea acuminata, Modiola gibbosa, Unio abductus, Mya, Isocardia striata, I. concentrica, Pleurotomaria,* and *Terebratulæ,* are found in great numbers. In the north of England (Carlton Bank, Yorkshire) the lower coal or lower Moorland sandstone, according to Murchison, consists of a great, local sandstone formation, with a large quantity of fragments of plants, which is placed between the inferior oolite and the grey "limestone" of Phillips. But the grey limestone of Yorkshire is merely what the Fuller's-earth of the south, the *Marnes à foulon,* and the *Marnes vésuliennes* also are, the δ. of the Swabian "brown Jura."

Am. coronatus is found in this bed, also *Perna, Terebratula biplicata, T. perovalis,* and spines of *Cidaris*; accompanied indeed by *Am. macrocephalus* and *Am. hecticus,* which with us make their first appearance in the succeeding stratum.

Normandy also makes an exception here in the parallelism of these strata. Above the light yellow limestones of the upper Lias with *Am. radians, Am. Thouarsensis,* and *Am. communis,* repose the beds of the *Oolite inférieure, Oolite de Bayeux,* or *terrain bajocien,* with their well-known abundance of shells. In the environs of Bayeux (to the W. and N.) this oolite forms a plateau, where it is exposed only in ditches and quarries. The largest quarries are near St. Vigor and Moutiers. Here the *Oolite inférieure* affords pretty well all the shells that in other parts are contained in the whole of the "brown Jura." But we must not imagine a great development of this deposit: there are beds of about 3 or 4 feet thickness, sometimes coarsely, and sometimes finely oolitic, of a yellow colour, and consisting almost of nothing else but fossils, and presenting in this narrow space everything that is contained at other places in a development of as many hundred feet. *Am. Murchisonæ, Am. discus, Am. coronatus, Am. Humphriesianus, Am. Parkinsoni, Am. hecticus, Am. Truellei, Am. subradiatus, Am. triplicatus, Am. planula, Am. macrocephalus, Am. Herveyi, Am. Brongniarti, Am. Gervillei, Am. bullatus, Am. microstoma, Hamites Parkinsoni,* and many others, *Pleurotomaria pyramidalis, Pl. cadomensis, Pl. ornata, Pl. decorata, Trigonia costata, Astarte obliqua, A. depressa, Ostrea pectiniformis, O. Marshii, Terebratula bullata, T. biplicata, Bel. giganteus,* and *B. canaliculatus* (*sulcatus*) may be collected in great numbers. To these must be added many rarer forms, as *Natica adducta, Melania vittata, Corbula, Arca, Auricula, Cardita, Crassina,* &c., all of which are in an excellent state of preservation. From what is here stated, we may perceive that this oolite of Bayeux is not comparable nor identified with any other bed, but is peculiar to Normandy. The Swabian geologist, who knows *Am. coronatus* and *Am. Humphriesianus* to be so absolutely separated from *Am. Parkinsoni,* and these again from *Am. macrocephalus,* by clays and shales lying between them, sees here in one bed of 4 feet in thickness all those shells together which at other places are typical of different beds; a clear proof, that in certain localities of the sea, animals of a different epoch, and elsewhere separated by strata, may occur in one deposit; and that the same depositions may continue at one place, which at another have been succeeded by others. By this, moreover, we perceive that we have in Calvados deep sea accumulations, whilst in England and Swabia littoral deposits occur. The synchronism, however, of the strata specified cannot be doubted.

Great Oolite. Bath Oolite. Bradford Clay. Forest Marble.

Grande Oolite. Oolite de Caen. Etage bathonien (D'Orb.). *Calcaire de Ranville.*

Haupt-Rogenstein.

This is the great mass of whitish yellow, oolitic rock, spreading from the south of England to the west of the Black Forest, and forming the distinct geognostic horizon of the "brown Jura." The whole mass consists of minute calcareous concretions like millet-seeds, more or less round, and more or less firmly cemented together. This rock, by its peculiar structure, its great development, its colour, and the great dearth of fossils, is everywhere easily recognised.

The Jurassic series of Swabia and Franconia, hitherto so perfect in its members, is herein deficient. This purely pelagic formation disappears eastward of the Black Forest, and here, as in northern England, is entirely wanting. But on the west side of the Black Forest, as soon as we descend into the valley of the Rhine, we perceive northward of Lahr the steep mass, near Freiburg, forming the Schöneberg, 2000 feet high. At Kandern we find also organic remains (*Echinidæ* and *Terebratulæ*). The Breisgau oolites are connected with those of Switzerland through the Wartenberg, near Basle, which latter often rise in high mountains. The whitish yellow oolites contain but few fossils, and that only in the upper beds, where *Galerites depressus, Nucleolites scutatus, Dysaster, Discoidea, Terebratula varians, T. biplicata, T. spinosa, T. quadriplicata,* &c., are found. From Switzerland to Mont Jura, from thence to Burgundy and the Haute Saône, and thence to the sea and beyond it, the Great Oolite is nowhere wanting. Sometimes with trifling, sometimes with great development, sometimes coarse, sometimes fine, it produces everywhere the most excellent building-stone. Sometimes it forms extensive plains, as in Calvados, near Caen; sometimes steep mountains and deep rock-valleys, as in Burgundy and the Jura, according to its greater horizontal or vertical development. In a quarry in the plains of Caen, called *carrière d'Allemagne,* bones and teeth of Fishes and Saurians frequently occur; which correspond perfectly to those of Stonesfield, near Oxford, where Fishes, Reptiles, and the celebrated *Didelphys Prevostii* have been found. In the year 1831, Murchison wished to identify these Stonesfield oolites with the beds at Solenhofen, but Voltz and v. Buch opposed this view, in order to combat the Anglomania of the German geologists.

Associated with the Great Oolite we generally find a compact, greyish blue, marble-like limestone, called Forest-marble. No distinct boundary between the two can be well made. In Mont Jura and in Burgundy these deposits pass into one another, the oolitic structure gradually making room for the compact, hard limestones. Here this Forest Marble attains a great development. Similar to the rude rock-masses of the "white Jura," which occupy the valleys of our Swabian Alps, the Forest-marble presents great rough projections. Rent into clefts, as in our Alps, it forms caves and grottoes, which are not inferior in beauty and size to those in Germany. The cave of Arcy, between Avallon and Auxerre, penetrates this rock. This formation, when greatly developed (Mont Jura, Burgundy), contains no fossils, but abounds with them when its development is less. The latter is the case in the west of France and in the south of England. The extensive quarries near Ranville (two leagues from Caen, near the Dives), disclose the beds belonging to the Great Oolite division. The great freestones which are sent abroad from these quarries are worked out of the Great-oolite, and in order to get to them, the Forest-marble, of 10–12 feet thickness, is removed; the latter is here filled with Corals, *Echinodermata*, and *Apiocrinites*.

In the south of England the Great Oolite is in force, presenting all the varieties of the rock; and at several localities it is rich in small and elegant shells. This is the case near Bath, Stonesfield, &c. Hence the name "Bath Oolite," which the French adopted, because even on the other side of the Channel the same stratum is to be found, near Luc for instance. This bed is a local formation of the Great Oolite; it is a snow-white, soft, oolitic limestone, very incoherent, and consisting almost entirely of shells and fragments of shells. This bed can be best observed between Luc and Langrune, three leagues north of Caen, near the sea-shore. The tide here eats into the shore, and the ebb-tide clears away the debris; towards the top of the 20–25 feet thick bed we find an immense abundance of *Terebratulæ*; *T. digona*, *T. biplicata*, *T. reticularis*, *T. plicatella*, *T. concinna*; also *Echinodermata*, as *Hemicidaris*, *Echinus*, *Galerites*, &c.; further down, there is a bed of bivalves, generally with the valves separate, such as *Nucula*, *Arca*, *Lima*, *Corbula*, &c. The whole bed is interlaced with Corals, with a strong base of *Astræa*, *Mæandrina*, *Lithodendron*, *Madrepora*, and *Scyphia*; *Serpulæ* are found in great quantities upon the shells, which are often entirely covered with parasites; small *Gasteropoda* and *Patellæ* are also present. On the other hand, the *Cephalopoda* seem to have become extinct, not a trace of them being found. Upon this local deposit of the Bath Oolite, there appears in the south of England another local formation, the "Bradford Clay," situated between the Great Oolite and the Forest-marble, full of the most beautiful fossils; this bed, however, does not find any parallel in other countries. In Wiltshire, especially in the neighbourhood of Bradford, we meet with a quantity of grey unctuous clays, with their organic remains in a most perfect state of preservation. Here are found *Apiocrinites intermedius*, *A. rotundus*, *A. elongatus*, *A. dichotomus*, with crown, stem, and root; also *Terebellaria ramosissima*, *Avicula costata*, *Terebratula coarctata*, *T. concinna*, *T. digona*, *Serpula triangulata*, *Lima*, *Gervillia*, *Modiola*, *Cidaris*, and others. The Forest-marble rests on the top of the Bradford clay. Stonesfield, already famous for its Great Oolite, exhibits a fine development of this stratum also [?]; we here find *Clypeus* and *Galerites*, *Millepora straminea* and *Ceriopora*, *Trigonia pullus*, *Pecten similis*, *Modiola imbricata*, *Ostrea*, *Pleurotomaria*, &c. But this bed already shows evidence of the general inclination of the English Jura to form sandstone, and at many places we find the hard marbles replaced by clay- and sand-beds. Towards the north especially do these sand-beds gain in force (Upper sand), in which *Pentacrinites vulgaris* and Plants are abundant. The sandstones in the Forest-marble of Wiltshire, near Castlecombe, frequently bear the markings of the tracks of small animals upon their greyish yellow laminæ. In Yorkshire these sandstones obtain at last such a development, that they surpass the whole Great Oolite formation, and resembling the "lower coal," now hold a separate place, as "upper coal" or "upper moorland sandstone," containing innumerable fragments of plants (twenty species of Monocotyledons and some Dicotyledons) between the grey limestone and cornbrash. And thus here, as in Swabia, the extensive Jura-sandstone formations have taken the place of the Great Oolite (Haupt-Rogenstein).

III. Upper Brown Jura, ε. and ζ.

ε { 1. *The clays of ε. Cornbrash limestone. Assise supérieur de l'étage bathonien. Dalle nacrée,* Thurm.
2. *The ferruginous oolite of ε. Kelloways rock. Callovien. Oxfordien inférieur,* D'Orb. }

ζ. *Oxford clay. Oxfordien moyen,* D'Orb. *Argiles de Dives. Marnes oxfordiennes.*

Above the greyish blue marly limestones with *Am. coronatus,* and the clays with *Belemnites giganteus,* there often appear in Swabia strongly developed black clays. They contain silicified Ammonites,—*Am. Parkinsoni, Am. hecticus, Hamites bifurcatus, Ostrea costata*; small Bivalves, *Trigonia costata, Pleurotomaria decorata, Trochus monilitectus, Turritella echinata*; a small *Anthophyllum, Dentalium,* &c. Above these lie hard limestones, generally with a number of *Terebr. varians*; and upon these a few feet of reddish brown oolitic beds, with *Am. macrocephalus, Am. triplicatus, Am. sublævis, Am. bullatus, Am. microstoma, Galerites depressus, Belem. latisulcatus,* and *B. canaliculatus.* The same is the case in the north-west of Swabia, for instance on the Lochen, where these beds are more particularly developed; but even at other places in Swabia we always find, between the *coronati-* and *macrocephali-*beds, that with *Am. Parkinsoni, Am. bifurcatus, Pholadomya Murchisoni,* and *Trigonia costata.* I believe that the black *Parkinsoni-*clays are best represented by the English Cornbrash, which may likewise partly represent the bed with *Am. coronatus*; because the Cornbrash contains greyish blue limestones and clays with *Pholadomya Murchisoni, Ostrea Marshii, Mya V-scripta,* numbers of *Terebratulæ,* and perhaps even *Am. Herveyi.* The fossils certainly do not correspond here, but only the position of the clay-bed directly underneath the Kelloways rock; but we see by the formation of this bed in different countries how the ε. of Swabia passes gradually over into the Cornbrash. The French Cornbrash has quite a middle position, which by no means accords with that of England; but on account of its contemporaneity the French have given it the English name. I did not find this formation in the west of France, but in the eastern parts, especially in Mont Jura. Here it consists of sometimes finely oolitic limestones, sometimes dark clays with small Corals and Bivalves, which, however, are found both in the upper and the lower portions, in consequence of which we cannot point out true typical shells. In Aargau and Basle first appear as characteristic forms *Am. Parkinsoni* and *Pleurotomaria decorata,* and also *Am. macrocephalus, Am. athleta,* and *Am. triplicatus.* On account of the fragments in the Shell-breccia partly retaining their natural lustre, Thurmann* calls it *Dalle nacrée.* These beds in Switzerland lastly make

* Essai sur les soulèvemens jurassiques du Porrentruy.

a decided transition to the Swabian *Parkinsoni*-clays. It is not, therefore, altogether incorrect to parallel these strata. As to age they seem to be the same, inasmuch as they everywhere underlie that important geognostic horizon, the *Callovien* or the *macrocephali*-bed. As far as I have examined the Jurassic series, I have never found these strata of more than a few feet in thickness; oolitic beds from a reddish brown to a yellow colour are never absent, and these, even if the lower beds deceive us, soon guide us again to the super-incumbent *ornati*-clays: and it is really astonishing to see in the organic remains of foreign countries, for instance the "Brown-Jura" fossils of the Himalaya and Cutch (*Am. triplicatus, Am. macrocephalus, Am. Gowerianus, Trigonia costata*, &c.) exactly the same red-brown colour, as if the specimens had been collected from the Kelloway of France or Germany. This bed of ferruginous oolite is of very general occurrence;—in the north of Germany, from the Maine to the Rhine, from the Rhine to the Loire, in Calvados, and in England: different typical shells, however, characterize the formation in the different countries. In France it abounds with *Am. Parkinsoni, Terebratula varians*, &c.; and *Am. macrocephalus*, together with *Am. ornatus* which lies above it, occur in a silicified state. On the other hand, *Am. macrocephalus* of Swabia is here so constant that it is never absent from this stratum even when but few feet thick. In Switzerland, however, the fossils of the *ornati*-clays already pass down into these oolites. At the Balmberge near Solothurn, near Bettlach, Valorbes, and the Bernese Jura, are found together with the fossils of the *macrocephali*-bed (these Ammonites excepted), calcified *Am. ornatus, Am. annularis, Am. athleta, Am. convolutus*, which all re-appear in a silicified state in the black clays. With this in France and England this formation commences. In Mont Jura and in Burgundy (Châtillon-sur-Seine) the *Callovien* occurs in considerable force. The rock remains always the same. As characteristic shells we have to notice *Belem. latisulcatus, Am. anceps, Am. triplicatus, Am. Jason, Am. cordatus*, and *Terebr. biplicata*. Here and there *Am. macrocephalus* is also found in Mont Jura. The same obtains in Calvados, near Dives, as also in England, namely, the shells of the *ornati*-clays already appear here; as, *Am. Calloviensis* (*Jason*), *Am. Duncani, Am. gemmatus* (*ornatus*), *Am. perarmatus, Am. athleta, Am. bifrons* (*hecticus*), *Am. Königii, Am. funiferus* (*Lamberti*), *Am. sublævis*, and *Am. macrocephalus*. Near Chippenham is also found *Crioceratites Parkinsoni* (*Hamites bifurcati*), [Ancyloceras Calloviense?] which in Swabia occurs lower down in the series.

If, however, the ferruginous oolites are palæontologically separable into a German and a French-English series, the formations of these countries unite again in the *ornati*-clays, the Oxford-clay, and the black unctuous clays with silicified shells. *Am. ornatus, Am. Jason, Am. annularis, Am. caprinus, Am. convolutus, Am. bipartitus, Am. hecticus, Am. Lamberti*, are found in them in the German Jura, but not all together at every locality. Already in Swabia are local differences with regard to the shells distinctly perceivable. *Am. ornatus* and *Am. bipartitus* occur principally between Neuffen and Lochen; they are also found singly at other places, but never in such size and abundance as near Neuhausen, Jungingen, Margarethhausen, and Lochen. On the other hand the variety of *Am. Jason* is here entirely wanting, which Ammonite is found most abundantly near Gammelshausen and Heiningen. *Am. Lamberti* is everywhere rather rare, as well as *Am. athleta* and *Am. Bakeriæ.* In Switzerland and Mont Jura the distribution of shells is quite different. Monte terribile, Belfort, Besançon, Salins, and Andelot are rich localities for the *ornati*-clays. The chief fossils here are *Am. Lamberti, Am. annularis,* and *Am. hecticus,* whilst our *Am. ornatus* and *Am. Jason* have disappeared, and are only found (silicified) lower down in the *Callovien. Belem. hastatus* is also general as a characteristic form.

These clays, exhibiting the above-mentioned palæontological differences, yet always remaining similar in appearance, extend through France (in Burgundy, where limestone predominates, they are here and there wanting) to the sea. Between Trouville and Dives these clays (*Argiles de Dives*) re-occur in full force in the lofty cliffs, called *Vaches noires,* formed of argillaceous and calcareous masses, and exposed to the continual erosive action of the violent breakers of that coast. Here sections of the strata from the Great Oolite upwards to the Greensand are exposed to view. Those of the "Brown Jura" consist of clay-beds, in which *Gryphæa dilatata* is found at almost every step. The brown oolitic Kellovian limestone-bed (erroneously named by the Norman geologists after the English "Calcareous grit"), with calcified *Am. Lamberti, Am. caprinus,* and *Am. perarmatus,* divides the black clays into two distinct portions, which have only *Gryphæa dilatata* in common. In the upper part we find silicified *Ammonites* (Oxford-clay), below the *Callovien* only Bivalves and Gasteropods (Cornbrash); the sea washes the shells out of the three beds, and throws them on the shore mixed together; in this case their respective beds are not recognised, and hence all which is black clay has been regarded as Oxford-clay. In the true Oxford-clay re-appear only *Am. ornatus* and *Am. Jason.* Here occur *Am. Lamberti,* very thick and large, *Am. sublævis, Am. athleta, Am. perarmatus, Am. caprinus,* and *Am. macrocephalus.* Everything is silicified and preserved with rare beauty; the size of the shells is especially to be admired; they surpass the Swabian specimens three or even six times. *Am. athleta, Am. perarmatus,* and *Am. Lamberti* attain 1—1½ foot in diameter, and are changed into pure quartz of metallic lustre. *Pecten fibrosus* and *Trigonia clavellata,* the latter forming whole beds above the clays, occur here, but are not found in Swabia.

The same conditions obtain on the other side of the Channel: *Am. athleta, Am. Jason, Am. sublævis,* and *Am. Comptoni* (*convolutus*) are characteristic in the environs of Oxford; at some places the chambers of the *Ammonites* are filled with white calc-spar. Christian Malford, near Chippenham, has yielded large supplies of the shells peculiar to this formation; they are mostly *ornati,* crushed, nacreous, and with the mouth well-preserved. *Am. Jason,* with a lip an inch long, is termed *Am. Elizabethæ*; the lip of *Am. convolutus* is quite as long. Together with these are also found, besides the *Ammonites* above referred to, *Belemnites* with almost perfectly preserved shells, impressions of Insects with other rarities; the fine and unctuous mud having particularly favoured their preservation. Lastly, in Yorkshire, as in Swabia, we again meet with silicified shells; and here are also found teeth of *Squalus, Crustacea, Astacus* (*Clythia Mandelslohi*) in the concretions of this bed.

With this the "Brown Jura" of Leopold von Buch closes. Here also the "Brown Jura" in Germany has its natural boundary; the lighter-coloured clays and limestones, which are now developed, announcing a new period,—that of the "White Jura."

In Switzerland and in France there is no absolute boundary between the "Brown" and the "White Jura," as was also the case in the transition of the "Black Jura" into the "Brown." Hence, that which constitutes the "Lower White Jura" in Swabia is so closely connected with the *ornati*-clays, that this name is used for the "Lower White Jura" in the non-German countries.

C. The White Jura.

A powerful development of this formation is peculiar to the German "Jura." Here it attains a thickness of above 1000 feet, whilst in England and France it is often scarcely 100 feet thick. The loss suffered by the Jurassic system in Germany by the absence of the Great Oolite and Forest-marble, is counterbalanced by the great development of the "White Jura." What the "Brown Jura" is for France and England, the "White Jura" is for Germany,—each having in the respective countries surpassed in development the other members of the Jurassic series. We here see how difficult it is to parallel all the strata of different countries. In particulars they differ entirely, and there only remain general similarities;—geognostically, the predominance of limestones;—palæontologically, the development of Corals and Echinoderms; the Cephalopods playing a less and less important part, and ultimately almost disappearing.

I. Lower White Jura, α. and β.

Marnes oxfordiennes supérieures.

On the *ornati*-clays in Swabia are superimposed alternations of clay and limestone to a thickness of 600 feet,—very regular and thin layers of white limestone traversing grey clays. In the lower clay-beds (α) *Terebratula impressa* is a very characteristic shell; there are also found small silicified *Am. planulati*, with *Rostellaria* and *Astarte*; whilst the limestones towards the top are characterized by *Am. polygyratus* and *Am. flexuosus*. I do not know a more instructive locality for the "Lower White Jura" than the Hunds-Rücken, a mountain 2800 feet high, eastward of Balingen, on the borders of Prussia and Wurtemberg. At the foot of the mountain, near the village of Streichen, are the *ornati*-clays, above which lie the light-grey limestones with *T. impressa*; the alternating limestones and clay-beds rise to the summit of the mountain, where we find in the white limestone-beds of a great steep precipice, the finest *Am. planulati* and *flexuosi*, *Belem. hastatus* with large *alveoli*, teeth of *Squalus*, &c. The presence, moreover, of fragments of wood and groups of *Algæ* is evidence of the former existence of an extensive shore-formation in Swabia. In Switzerland and in Mont Jura, *T. impressa* is found towards the top in the clays containing *Am. Lamberti* and *Am. ornatus*. This bed, therefore, so extensive with us, is reduced to a minimum in the French "Jura," and is comprehended under the name of *Marnes oxfordiennes*.

Beyond Burgundy a trace only is to be found either of this or of the succeeding formation.

II. Middle White Jura.

Scyphia-limestones and Lacunosa-beds.
Terrain argovien. Terrain à chailles.

From out of the regularly stratified limestone-beds in Swabia spring up a great many coral-reefs, upon which again, at some places, repose regular limestone-strata. This Division of the "White Jura" is the natural continuation of that below, for it retains *Am. planulatus*, *Am. flexuosus*, and *Belem. hastatus*. In the coral-banks of the "Lower White Jura" lived numbers of small *Mollusca* and *Radiata*, such as are always found on coral-reefs. As regards the German "Jura," this bed is one of the most important, for the development of these coral-reefs contributed, without doubt, largely to the whole formation of the Alpine margins. The Spongites-beds are chiefly developed in Swabia and Franconia; from thence they may be traced through Switzerland to Mont Jura as far as Burgundy, with a gradual loss of force. At many places in Switzerland, as near Andelot, both beds lie directly over the *ornati*-clays, within a distance of 8—10 feet, the latter containing *Am. Lamberti* and *T. impressa*, calcified *Am. planulati*, *Scyphiæ*, *Cnemidiæ*, and *T. lacunosa*. The last place I met with *T. lacunosa* and the *Spongites* was at Châtel Censoir (Dép. Yonne), where the celebrated collection of M. Cotteau is. Here the *ornati*-clays, as well as most of the argillaceous beds, have disappeared, and on the top of the Forest-marble and the Great Oolite lies the fissured, marble-like limestone with *Spongites*, and immediately upon that the bed with *Cidaris Blumenbachii*, *Apiocrinites Milleri*, &c.

Further from hence we find no trace of this bed, either in Normandy or in England. Mr. J. Toulmin Smith* is at present engaged in more particularly examining the sponges in the British Museum from the Randen; and I understand that he has never seen similar forms from the Jurassic rocks of England, but that in the Greensand he finds many species that are related to the Spongites of our "White Jura."

The "Middle White Jura," closely connected with the "Lower," is to be particularly looked upon as a German formation, generally characterized by *Am. planulati*, *Ter. lacunosa*, and Sponge-corals. Corals, the indication of a shallow sea, would only first spring up from the sea-bottom after the "Lower White Jura" deposits had approached the sea-level. The accumulation of clay was greatest in Franconia, Swa-

* [Compare Mr. J. Toulmin Smith's 'Ventriculidæ of the Chalk,' pp. 42, 43. —Transl.]

bia, and Switzerland, traces of which continue even over Mont Jura into Burgundy; the sponge-beds, however, always keep pace with the argillaceous accumulations. The Mont Jura geologists call the formation *Terrain argovien* in consequence of its extensive development in Aargau, and comprehend in this the Lower and Middle "White Jura," considering the coral-reefs to be local and unimportant accompaniments of the clay- and limestone-beds.

In this category likewise falls a local formation peculiar to the Swiss "Jura," the *terrain à chailles*, a bed so rich in quartz that most of the fossils are silicified. These shells partly remind us of the Oxford-clays; they are, *Am. cordatus, Am. convolutus, Gryphæa dilatata, Trigonia clavellata, Terebr. biplicata,* and *T. lagenalis,* with *Apiocrinites* and *Pentacrinites.* This formation is clearly local, and finds no parallel in other countries; here, however, it occupies the place where in the German "Jura" an indication of the same fauna appears. The greatest similarity of the *terrain à chailles* exists palæontologically with the Lower Calcareous Grit of Yorkshire, a local formation between the oolitic Coral-rag and the Oxford-clays, and in which also *Am. cordatus, Am. convolutus,* and *Gryphæa dilatata* are typical shells.

III. Upper White Jura.

Massive limestones [*plumpen Fels-kalke*]. *Coral-rag. Groupe corallien. Saccharoid limestone. Marble. Dolomite.*

The unstratified masses of the Upper "White Jura" throughout Germany, and as far as Burgundy, constitute a good geological horizon. They form the picturesque rocky valleys of the Swabian and Franconian Alps, and their fissures give origin to the celebrated caves. These rocks are almost destitute of fossils; in the upper portion, however, there appear a few Corals, *Radiaria,* and *Terebratulæ.* The English Coral-rag has been compared to this formation, so characteristic of the German "Jura;" and indeed these unstratified rocks have had this name applied to them; but quite erroneously, for in England and the north of France the Upper "White Jura" is always bedded, and nowhere resembles the bold, massive rock-ridges of the German "Jura." In the south of England the Coral-rag consists of a hard, bluish-grey limestone, of a few feet in thickness, full of *Ostreæ, Cidarites,* Corals, and fragments of shells, passing upwards into the Coralline Oolite, which occurs in somewhat greater force. In the neighbourhood of Oxford it lies immediately upon the dark Oxford-clays with *Am. perarmatus* and *Am. ornatus.* In the north of England also this formation is stratified, and we find that the calcareous beds of the Coralline Oolite are separable into three divisions. The lowest bed is the Lower Calcareous Grit, distinguished by a great many small Bivalves, *Gryphæa dilatata,* and *Ammonites,* which already in the Oxford-clays are found silicified. There are not yet any Corals; these first appear in the Coralline Oolite, lying above it, and, together with the accompanying fossils, remarkably agree with those of the German "Jura." We here find *Anthophyllum obconicum* (*Turbinolia dispar,* Phill.), *Manon capitatum* (*Spongia floriceps*), *Lithodendron* (*Caryophyllia*) *cylindrica, Astræa helianthoides, A. alveolata, A. tubulifera; Cidarites coronatus* (*florigemma*), *Echinus germinans, Clypeus emarginatus, Spatangus ovalis; Apiocrinites Milleri, A. subpentagonalis; Trochus; Turbo; Nerinæa; Am. inflatus, Am. perarmatus,* and *Am. planulati.* The third division of the Coral-rag forms the Upper Calcareous Grit, which is not, however, found everywhere; this, like the Lower Grit, is characterized by a quantity of small Bivalves and fragments of shells. The same obtains in Normandy, where near the coast, between Caen and Honfleur, as also in the interior, near Lisieux in the Mortagne, the whitish-yellow oolite of the Coral-rag is found in considerable extent, but in little force. *Radiata* in particular appear here, and a bed full of *Trigonia clavellata* separates this formation from the *Argiles de Dives.* Here, as in the German "Jura," the absence of Cephalopods, and the predominance of Corals, *Radiata,* and Bivalves related to *Ostrea* form a well-marked horizon; in the German "Jura" the absence of all bedding and the massive character of the formation clearly mark out the horizon and that indeed the last in the "Jura," for henceforth the formations undergo great variations, the examination of which is the most difficult of the whole Jurassic series. We have especially to guard against any expectation of placing the beds of different localities in any one order of succession; so as to say, for instance, that *Diceras*-limestones lie above or beneath the Solenhofen-slates or below the Portland-oolite. These are, rather, three separate and peculiar Forms, lying side by side.

We may, perhaps, best comprehend the Divisions of the "Jura" above the Coral-rag by the *ensemble* of the organic remains; we will therefore consider first the Coral-*facies,* secondly the Mollusc-*facies,* and thirdly the Vertebrate-*facies.*

1. *The Coral-facies.*—The unstratified "White Jura" is not overlaid by any more extensive bed, and forms the last member of the Jurassic series. This is sometimes the case over wide tracts; sometimes it only offers prominent isolated spots and ancient coral-reefs and shores, in whose basins and creeks the younger, stratified Jurassic rocks repose.

In the Franconian "Jura"-range from Staffelstein to Parsberg the Dolomites are not overlaid by any other Jurassic bed; for they are everywhere covered with post-tertiary formations, often immense accumulations of shingle-sands [Geschieb-Sande] (Hastings-sand?), above which here and there on the dreary plateau projections of the Dolomite appear, whilst the massive Dolomite is exposed in the valleys. The same is the case upon the road from the Wisen Valley (Muggendorf and Streitberg) to Amberg. And we find that the Dolomite of the Heights, when broken, exhibits traces of Corals and *Terebratulæ.* Generally, however, isolated tracts and points only of this rock occur, and these have often surrounded in extensive semicircles the basins of the Jurassic beds, and afforded protection to the precipitations of the fine mud that formed the Solenhofen-slates. Of such spots the Swabian "Jura" presents a great number between the Randen and the Ries, where we may observe the unstratified calcareous masses lying side by side with the stratified Lobster-claw-shales; the latter leaning against the former. These are often excellent places for the finding of fossils, whenever quartz (everywhere so common in the Upper "Jura") affects the Corals and shells; especially the old pit of St. Margaret, upon the Heights between Nattheim and Heidenheim. Other such places in Swabia are the Heights near Pappellau, Blaubeuren, Arnegg, Sirchingen near Urach, Mess-stetten, and Nusplingen. Asteroid Corals [Stern-Korallen] forming these reefs are *Astræa, Mæandrina, Lithodendron, Anthophyllum, Explanaria,* and *Agaricia*; characteristic *Apiocrinites* and *Cidarites* are also always present. But this Form of the Star-Corals is not the only one; the appearance at some places of the cellular and tubular Corals, accompanied with Univalves and Bivalves, forms the transition to the Mollusc-*facies*. This Coral-group [Korallen-Form] is the more remarkable, as with it is associated a Bivalve—the *Diceras*—which has always attracted the attention of geologists. The appearance of this shell is marked by two peculiarities; it is never, for instance, found without those massive cellular and tubular Corals (*Columnaria* and *Calamopora*), which form entire rocks, and then only at those localities where some limestone overlies the "Jura." The *Diceras* is a very rare form, and in the German "Jura" is only found at Kelheim and Ratisbon, where, upon the Heights around the valley-declivities of the Danube, Laaber, and Naab, a series of snow-white limestones, full of remarkable forms which are found nowhere else in the "Jura," lie above the Dolomite. Complete specimens, however, are very rare, and of these most are merely casts. *Chama Münsteri, Diceras arietina, Terebratula inconstans, Lima gigantea, Mytilus amplus, Nerinæa, Natica, Pteroceras,* &c. are most generally found. The rarer forms are *Caprotina*-like Bivalves and *Modiola lithophaga*; amongst the *Gasteropoda, Tornatellæ* and *Nerinææ*, reminding us of Gosau and Abtenau; and lastly, *Pollicipes Nilssoni* and *P. rigidus* at Ebenwies. These *Diceras*-limestones are not separated from the underlying Dolomites; there is an almost imperceptible transition of the Dolomite into the Limestone, and frequently the *Diceras* is seized upon by the former. No other Jurassic bed overlies the Limestone, but above it we find the Greensand-strata with the well-known *Exogyra columba*, and we clearly perceive that the *Diceras*-limestones form the only and last Jurassic strata between the Dolomite and the Chalk.

On comparing the phænomena of the French "Jura" with this locality, we are struck with the similarity of the formation. Between the celebrated grotto of Arcy (Yonne) and Châtel Censoir, we ascend the mountain over massive rocks containing *Am. planulati* and *Terebratula insignis*; arrived at the summit, we find it covered with snow-white, softish limestone, consisting almost entirely of cellular and tubular Corals, *Nerinææ*, and *Dicerata*. In the vicinity, however, the Chalk-formation, which surrounds the whole Paris-basin, crosses the Yonne, and further on the Loire. The conditions of the Mortagne de la Sarthe, from whence are obtained the pretty little *Diceras*-casts, are the same. The *Diceras* is also found at Pagnoz in Mont Jura and in the Swiss "Jura," in the vicinity of the Neocomian. But in the Swabian "Jura" we may in vain look for its existence, because here there is not a trace of chalk, and the Star-coral-*facies* is developed in the Upper "Jura." In like manner as the zoological character of the *Diceras* (according to Ewald) unites the Bivalves of the "Jura" with those of the Chalk, so also, in a geological point of view, this shell, by its occurrence only in the vicinity of the Cretaceous Formation, is an intermediate link between [vermittelt] these two extensive systems. The *Diceras*-group with the Pillar-corals, as a parallel to the more common Star-coral group, constitutes, together with the latter, the important and far-spread Coral-*facies* of the Upper "White Jura;" and it forms also, by its being connected with Molluscs of all kinds, the transition to the second great *Facies*.

2. *The Mollusc-facies.*—Where the before-mentioned unstratified rock-masses [plumpen Fels-Massen] are not covered by Coral-reefs, they are overlaid with extensive calcareous strata, often in great force, in which Univalves and Bivalves play the principal part. We soon meet with Oyster-banks, *Exogyræ*, warning us of our approach to Chalk, sometimes with beds of *Gasteropoda* and *Dimya*; here once more with the gigantic Cephalopods, there with little fragile Bivalves. In Germany this condition obtains in the North only,—in Hanover and Brunswick. We find it mostly developed in Switzerland and in Mont Jura, where the stratified Upper or "White Jura" far surpasses all the other members of this formation, and where whole mountains are formed of hard, whitish-yellow, marble-like limestone-masses. From thence it traverses France, being at a few places only interrupted by coral-banks, enters Calvados, crosses the Channel, and immediately in the south of England forms the peninsula of Portland; thence it extends northwards as far as Yorkshire, where Corals again appear.

We find three principal names applied to this *Facies*; "Sequanian," "Kimmeridge," and "Portland," which will serve to point out its most important local modifications. In the Bernese Jura and Mont Jura, for a better knowledge of which science is especially indebted to Thurmann's researches in Bruntrut, immediately above the Coral-rag appear whitish-grey clays, alternating with calcareous shales, the latter especially increasing in force towards the top. This is the *Groupe séquanien*, characterized by *Astarte minima*, *Apiocrinites Meriani*, and *Exogyra Bruntrutana*. The alternation of whitish-grey clays and compact limestones of the same colour continues also through the two following groups, the "Kimmeridge" and the "Portland;" no mineralogical differences can be anywhere observed, the separate groups being characterized only by the different organic remains. In the "Kimmeridge," which is next in order, the Acephalous Fauna is represented; *Ostrea solitaria*, *Ceromya*, *Pleuromya*, *Pholadomya Protei*, and *Ph. truncata* occurring in these clays; whilst in the clays of the "Portland," numbers of Gasteropods, *Pteroceras*, *Natica*, and *Nerinæa*, have been principally developed. These three groups, however, continually pass into one another, and their boundary-lines, owing to the many overthrows and dislocations, are either with difficulty, or not at all to be found. Indeed this grouping results rather from the necessity of systematizing these great masses, so similar in external characters, than from the presence of any really existing divisions.

In Burgundy it is chiefly at Auxerre and the neighbourhood that there lies above the unstratified rock-masses a system of regular calcareous beds; these are of a whitish-yellow colour, and are used for paving purposes. Small molluscs are here entirely wanting; but the following are characteristic: *Perna plana* (*Mytilus amplus*), *Am. gigas*, Sow. (a gigantic *planulatus*, forming a passage to *Am. coronatus*), and *Nautilus giganteus*. These limestones are called "Kimmeridgian;" and a hard white limestone with *Exogyra virgula*, lying above it and bearing the Neocomian clays, is termed "Portlandian." In Calvados, above the Coralline Oolite, we sometimes again find oolitic limestone, sometimes black clays, in neither case extensively developed,—and indeed this is generally the case with the "Jura" in this country. The oolitic calcareous marls commence near Port-l'Évêque, where the Tronques passes through the country, and extend inland over Lisieux; there they are mostly used for the manufacture of cement. The yellow marls are towards the top filled with casts of *Mya*, *Venus*, *Lucina*, *Cardium*, *Pinna*, *Modiola lithophaga*, *Pteroceras*, *Natica*, and *Nerinæa*, and contain also *Cidarites* and *Echinites*; whilst in the Oolite beneath, *Perna*, *Pinna*, *Trigonia clavellata*, *Astarte*, and *Venus* are abundant. As numerous Corals are also present, this latter bed ought rather to be associated with the Coral-rag. Parallel to this bed appear the clays of the Tronques Valley, which constitute a passage to the English formations, where above the Coral-rag lie dark Kimmeridge-clays, and above these the light-coloured Portland-limestones and Oolite. Near the village of Mault, or between Honfleur and Trouville, we find the last Jurassic beds of this locality,—black clays, *Argiles de Honfleur*, full of Bivalves, as *Myæ*, *Lucinæ*, &c., having white shells, but mostly crushed and fragile. In like manner the Kimmeridge-clay is represented in the south of England by black or bluish clays; for instance, near Oxford, where at the large quarries in the Coralline-oolite, which supply building material for Oxford, the dark Kimmeridge-clays have to be first removed. *Am. planulati*, *Terebratulæ pugnaceæ*, *Trigoniæ* with concentric rings, and especially *Ostrea deltoidea*, are found here in great quantities. It is also to be remarked, that here, as well as in Calvados, these dark clays are full of small clear crystals of Gypsum, which are found nowhere else, and which may be regarded as characteristic.

Lastly, in the south of England the "Jura" Formation concludes with the Portland-stone; a light-coloured limestone and oolite, occurring in much force at Portland on the top of the dark Kimmeridge-clays. *Ammonites planulati* (*Am. gigas*, *Am. biplex*), *Buccinum naticoides*, *Terebra Portlandica*, *Nerita angulata*, *Trigonia incurva*, *Tr. gibbosa*, *Perna ampla*, *Pecten lamellosus*, *Ostrea falcata*, *O. expansa*, *Astarte cuneata*, *Cardium dissimile*, and *Columnaria oblonga* are regarded as characteristic by the English geologists. Near Oxford I found the Portland-stone as a bed of white calcareous marl, of a few feet only in thickness, with *Am. planulatus* and fragments of some Bivalves. The limit between the Portland-beds and the Kimmeridge-clay is sharply defined.

Thus we find the Portland-stone as a peculiar local formation, absent in the North of England, and nowhere repeated on the Continent. The North-German "Jura"-formations of the Langenberg, and the above-mentioned limestones of France and Switzerland have certainly been termed "Portland," and attempts have even been made to apply this name to the Swabian and Franconian calcareous beds; but this general use of the term is quite erroneous; for there exists not the least similarity either in a mineralogical or a palæontological point of view between the Portland-stone of England and the so-called "Portland" of France, Germany, and Switzerland; and it was only the somewhat similar succession of the strata, or the natural feeling to apply to the last bed of the "Jura" one and the same name, which led to this misuse of the term "Portland." The Portland-stone is only a portion of the great series of strata forming the Mollusc-*facies* of the Upper "White Jura."

3. *The Vertebrate-facies.*—The zoological succession now leads us to the Group [Form] of the Upper "White Jura" in which *Articulata* and *Vertebrata* appear. *Crustacea* and Fishes here play the principal part. The only representatives of the Molluscs are the Cephalopods. But geognostically this *Facies* is connected with the first, the Coral-*facies*; because this higher Fauna has been developed only in bays and creeks protected by Coral-reefs. Only at the bottom of the most tranquil seas could such laminated beds, as the valuable Lithographic Shales, have been formed of the finest calcareous mud. Between the Randen near Schaffhausen and the "Jura" heights near Ratisbon, at the side of the great Coral-reef which extends N.W. and S.E., and above the massive Marbles and Dolomites, lie a series of calcareous beds, of finer or coarser grain, in smooth thin laminæ or in much thicker slabs. In Swabia these beds are much coarser, intersected with calc-spar veins, not splitting regularly, and alternating with clays; but the Franconian beds are of a much finer substance, more homogeneous and harder; they are, however, easily distinguishable at both places from the other Jurassic rocks by the clear sound they give when struck with a hammer. Only the Franconian slates are used for lithographic purposes, the most celebrated being those of Solenhofen and Mernsheim; attempts have also been made to use the Swabian schists for this purpose, but without success. The juxta-position of these laminated beds with the Coral-rag may be observed at many places; and we often see the reef-like rocks, isolated, in groups, or in rows, projecting above the horizontal shales. Thus, the Herdtfeld consists of a large basin everywhere surrounded by reefs of Coral-rag. At Solenhofen and Mernsheim, we can see that the shales lie lower than the projections, and yet above the mass, of the Dolomites. Near the Mernsheim ruins, we see, upon the summit, rocks with *Terebrat. inconstans* and *T. trilobata*; at the side and below are the lithographic slate quarries, penetrating into the rock. Near Kelheim, Randeck, and Kelheimwinzer the *Diceras*-limestones so clearly pass into the Fish-slates, that no doubt can exist that the two beds lie side by side. The laminated beds here penetrate into the Limestone or the Dolomite, or they alternate one with another.

The remains of animals of higher orders occur in this slate; Fishes, *Crustacea*, Insects, *Sepiæ*, and *Ammoneæ*. In Swabia the great quantity of Lobster-claws is everywhere characteristic, whence the appellation of these limestones, and Fish-scales, *Lumbricaria*, *Aptychus**, and *Ammonites* are also found. At some places, as near Ulm and Einsingen, we perceive a transition into the Mollusc-*facies*. The *Vertebrata* first begin to be abundant in Franconia; where, however, there are so many local peculiarities, and so many shades and transitions from one to another, that in a monograph of these formations a correct account of the localities is necessarily very important. These local variations of the character of the rock without doubt depended upon the influence of fresh-water; which may also have caused the fineness of the calcareous mud, the riband-like stripes on the laminæ, and many other phænomena. Fish are more especially found at Solenhofen; but even here each of the numerous quarries has its particular production. In one we find "Spiesse" (lances) and "Sonnen" (suns) (*Loligines* and *Ammonites*), in another "Spinnen" (Spiders) and "Klauen" (claws) (*Comatulæ* and *Aptychi*), here Crustaceans, there Fishes, and so on. Eichstadt is remarkable for the number of Insects (427 slabs with Insects are exhibited in the Leuchtenberg Cabinet), *Libellulæ*, *Cicadæ*, *Cimices*, and *Blattæ*; there are also beds of Crustaceans, Fish, and *Gorgoniæ* distributed in different quarries. Kelheim produces the finest *Pterodactyli*, *Aspidorhynchi*, and other splendid specimens, the white chalk-like matrix being here favourable to fossilization. As belonging to this *facies* of the Upper "White Jura" in other countries we might reckon Solothurn with its Turtles and Fish-teeth, and Tisbury in Wiltshire, where Lobster-claws and Fishes are found in the neighbourhood of coral-banks.

Into so many different groups and local formations do we see the last member of the Jurassic series divided! How different the conditions of these *last*, compared with the *first* beds—the *arietes*-beds—of the "Jura!" The latter possessed a family of *Ammonites* with millions of individuals, a *Gryphææ*- and *Thalassites*-bed with innumerable specimens; and these, in a homogeneous blue limestone, uniformly spread through all the countries in which the "Jura" appears;—in the former, on the other hand, are found numerous families, genera, and species from all the Classes of the Animal Kingdom; and that, in strata of such manifold varieties, that the identity of the rocks will no longer be found to agree in any two countries! If at any time, then surely in the Jurassic Period did the climate make a giant-step in advance, educing multiplicity from out of a long-fixed uniformity. With this climatal change the formation of Corals in the Jurassic epoch is certainly connected. Where no Corals exist, and where we find pure pelagic deposits in extended horizons, there appears only the Mollusc-*facies* in its somewhat narrow boundaries,—the characteristic condition of most of the Jurassic formations (Sequanian, Kimmeridgian, and Portlandian); but where Coral-reefs are developed the different Faunæ are called into existence. On the coral-

* [See Strickland on *Aptychus*, Quart. Journ. Geol. Soc. vol. i. Pt. I. p. 232, and Von Buch and Burmeister on the same, *ibid.* vol. vii. Part II. p. 32. Also Von Buch, Bulletin Soc. Géol. de France, 2nd Ser. tom. vi. p. 566.—Transl.]

banks the smaller Molluscs and the *Radiata* are abundant; in the larger circle of the atolls and lagoons exist numbers of Fish and Crustaceans; and on the shores Reptiles, Insects, and freshwater animals. In no other Period does the climate undergo so great a change;—in no other Period do so many new species appear upon the Earth; and no other Period possesses so much importance with respect to the history of our planet, as that of the "Jura."

With this I conclude the comparison of the "Jura" in the countries mentioned. Each has its peculiar predominating formations, surpassing the other members of the Jurassic series. In the North of England there are generally great sandstone-formations, that throw the clays and limestones into the background; in the South of England and in the West of France it is oolite, in the East of France and in Switzerland limestones, and in Swabia it is the clays that predominate. A formation, capable of being identified by geological succession and by organic remains, may appear in different countries sometimes as sand or clay, sometimes as a limestone or an oolite. Still there are not merely differences in the characters of identical strata, but there are strata geognostically distinct from others. This is the case with the Great Oolite, which is so important in the English and French "Jura," but entirely wanting in Swabia and Franconia. This important group, often developed more extensively than the whole of the other accompanying Jurassic Formations, supplies the "Jura" with an additional link in its chain, and influences its geological division. Of the four principal Divisions of the "Jura,"—Lias, Oolite, Oxfordian, and Corallian,—or Lias, Lower, Middle, and Upper Oolite, the Great Oolite and the beds above it as far as the Coral-rag have been taken together to form the third Division; the Coral-rag and the superincumbent beds constituting the fourth or last part. In the German "Jura" the relative proportions are quite different: here, where the Great Oolite is wanting, we must make two groups of our "Brown Jura;" viz. Oolite and Oxfordian, which can bear no proportion in development to the "Black" and the "White Jura." The other principal difference arises from this,—that the clays and limestones of the Lower and Middle "White Jura" and the *Spongites*-beds are entirely wanting in the Jurassic series of France and England. In Swabia "Oolite" is wanting; instead of it there is the "White Jura." In France and England "Oolite" is present, but those members of the Lower and Middle "White Jura," that are so important in Germany, are absent; for in England and the West of France the Coral-rag lies immediately above the *ornati*- or Oxford-clays. In Swabia the *Spongites*-beds and the Coral-reefs of the ancient German Sea form the *centrum*, to which the rest of the "White Jura" is subordinate. They form the summits and, for the most part, the mass of the Alps, whilst in England and the North of France the "White Jura" commences with the Coral-rag. Thus then, in the north-west of Europe it is chiefly the "Oolite" formations which characterize the "Jura"; whilst in Germany the "White Jura" (the *Spongites*-beds) is characteristic. The "White Jura" might, perhaps, be extended much further to the Alpine limestones of Provence, Italy, and Austria. Victor Thiollière, through Quenstedt's "Flötz-

Gebirge" and "Petrefakten Deutschlands," has drawn attention to and studied the Provençal Alps; and in the before-mentioned work "*Sur les terrains jurassiques de la partie méridionale du bassin du Rhône**," he has defended the opinion that the Alpine limestones with *Terebrat. diphya* and *Am. Tatricus*, and, further on, the red marble-like limestone of Italy, are nothing but the equivalents of the Swabian *Scyphiæ*-limestones. *T. diphya* and *Am. Tatricus*, he observes, are found in the Lias, in the Oxford-group (*i.e.* the Middle "White Jura"), and in the Neocomian; they characterize the "Jura" in the Mediterranean district (*le jurassique méditerranéen*), but not any single formations.

The above-mentioned limestones, called also the Crussol- and Porte la France-limestones, more especially contain *Am. polygyratus*, *Am. polyplocus*, *Am. biplex*, *Am. flexuosus*, *Am. hecticus*, *Belem. hastatus*, *Aptychus imbricatus*, *Terebrat. lacunosa*, and *T. nucleata*†, all characteristic of the "White Jura." Even if the Sponge-corals are wanting in the Alps, this must not mislead us. Corals can never be characteristic of Formations; they appear, rather, everywhere if climatal conditions have been favourable; and the *Spongites*-limestones of Germany were only another *Facies* of the sea which in the South of Europe has formed the Alpine limestone. With this view the stratigraphical order of the other Jurassic Formations agrees; for in Provence below the Alpine limestone the *ornati*-clays with *Am. Parkinsoni* occur; lower down the *opalinus*-clays and the Lias. This Jurassic group extends in France from the Mediterranean, along the Cévennes and the Alps, to Mont d'Or Lyonnais and in the north of the Isère-Département, where the Form of the English-French "Jura" commences. If now, in the latter Jurassic range "Oolite" is pre-eminently developed, and in the North of Europe (Russia) the "Brown Jura" predominates, it seems that the German "Jura" forms the transition from the "Jura" of the North to that of the South, where the "White Jura" has its chief development. The English-French Gulf of the Jurassic sea, in the middle of which we now find the Paris and London basin, constitutes with its "Oolite" formations an isolated group analogous to that of the Northern "Jura" with its masses of "Brown Jura." The Fauna of the North exhibits but slight differences; but the contrary obtains with the formations and inhabitants of the Southern Jurassic sea, stretching over Italy and Greece, towards Africa and Asia. In the middle, between North and South Europe, lies the German "Jura," separated from that of the North-west by the absence of the "Great Oolite," but generally containing in itself the substances of the Northern and the Southern "Jura," and at all events forming by its coral-banks the north edge of the southern Jurassic sea.

The following Tables afford a general survey of the contemporaneous Formations of the "Jura" in descending order in Franconia, Swabia, France, and England; and the vertical development of the respective Formations is in a general way typographically expressed.

* Bullet. de la Soc. Géol. de France, Séance 8 Nov. 1847.

† Quenstedt, Petref. Deutsch. p. 264.

TABLE I.—The White

Franconia.	Swabia.	Switzerland and the Jura.
	Molasse.	
Greensand.	Solenhofen Schists or Crabs-claw Beds. Aptychus. Tereb. pentagonalis. Blue Clays. Nattheim Coral Schist. Anthoph. obconicum. Lithod. trichotomum. Astræa. Apiocrinites Milleri. Cidarites coronatus. Nerinæa depressa. Massive Rocks. Tereb. insignis.	Neocomian.
		Portlandian Group. Limestone and marls. Exogyra virgula. Nerinæa trinodosa. Trigonia concentrica. Kimmeridgian Group. Limestone and marls. Pholadomya Protei. Mya. Perna plana. Trigonia plicata.
Limestones. Diceras. Natica. Mytilus amplus. Ter. inconstans. Corals. (*Ratisbon.*) **Schists.** Fish. Crustacea. Sepiæ. Ammonites with Aptychus. (*Solenhofen.*)	Marble. Dolomite. Saccharoid Limestone. Caverns.	Sequanian Group. Limestone and marls. Astarte minima. Apiocr. Meriani. Natica. Rostellaria. Ostrea Bruntrutana, et sequana, *Thurm.*
Dolomite and Marble.	Belemnites hastatus. Spongites Bed. Tereb. lacunosa, &c. Am. alternans, polyplocus. Eugeniacrinites. Pentacr. cingulatus. Scyphiæ.	Corallian Group. Nerinæa Bruntrutana. Cidaris coronata. Apiocrinus Milleri. Astræa. Anthophyllum. Lithodendron. Facies à chaille.
Terebratula lacunosa. Scyphiæ. Pentacr. cingulatus.	Clays and Calcareous Beds. A. polygyratus, flexuosus.	A. biplex.
Laminated Limestones, with Am. planulati.	Clays, with Terebratula impressa.	Argovian Group. Spongites. Tereb. impressa.

Jurassic Series in

Burgundy.	Normandy.	South-England.	North-England.
Neocomian.		Hastings Sand. (Purbeck Stone.)	Greensand.
Portlandian Limestone. Exogyra virgula. Kimmeridgian Schistous Limestone. Perna. Pinna. Am. gigas.	Greensand.	Portland Stone. A. biplex. Buccinum naticoides. Terebra Portlandica. Trigonia incurva. Perna.	Kimmeridge Clay. Plants.
Diceras. Corals. Corallian.	Honfleur Clays.	Kimmeridge Clay. Ostrea deltoidea. Plants.	Oolite. Turbinolia. Caryophyllia.
Argovian Group. T. lacunosa. Spongia.	Mya. Trigonia. Coral Rag Oolite. Ter. insignis. Cidaris. Hemicidaris.	Coral Rag Oolite. Cidaris. (*Heddington*, &c.) Calcareous Grit.	Coral Rag. Astræa. Apiocrinus Milleri. Cidaris. Calcareous Grit. Am. perarmatus.

Table I.—The White Jurassic Series in

Franconia.	Swabia.	Switzerland and the Jura.	Burgundy.	Normandy.	South-England.	North-England.
	Molasse.					
	Solenhofen Schists or Crabs-claw Beds. Aptychus. Tereb. pentagonalis. Blue Clays.	Neocomian.				
	Nattheim Coral Schist. Anthoph. obconicum. Lithod. trichotomum. Astræa. Apiocrinites Milleri. Cidarites coronatus. Nerinæa depressa.	Portlandian Group. Limestone and marls. Exogyra virgula. Nerinæa trinodosa. Trigonia concentrica.				
Greensand.	Massive Rocks. Tereb. insignis. Marble. Dolomite. Saccharoid Limestone. Caverns.	Kimmeridgian Group. Limestone and marls. Pholadomya Protei. Mya. Perna plana. Trigonia plicata.	Neocomian.		Hastings Sand. (Purbeck Stone.)	Greensand.
Limestones. Diceras. Natica. Mytilus amplus. Ter. inconstans. Corals. (*Ratisbon.*) Schists. Fish. Crustacea. Sepiæ. Ammonites with Aptychus. (*Solenhofen.*)	Belemnites hastatus. Spongites Bed. Tereb. lacunosa, &c. Am. alternans, polyplocus. Eugeniacrinites. Pentacr. cingulatus. Scyphiæ.	Sequanian Group. Limestone and marls. Astarte minima. Apiocr. Meriani. Natica. Rostellaria. Ostrea Bruntrutana, et sequana, *Thurm.* Corallian Group. Nerinæa Bruntrutana. Cidaris coronata. Apiocrinus Milleri. Astræa. Anthophyllum. Lithodendron.	Portlandian Limestone. Exogyra virgula. Kimmeridgian Schistous Limestone. Perna. Pinna. Am. gigas.	Greensand.	Portland Stone. A. biplex. Buccinum naticoides. Terebra Portlandica. Trigonia incurva. Perna.	Kimmeridge Clay. Plants.
Dolomite and Marble.			Diceras. Corals.	Honfleur Clays.	Kimmeridge Clay. Ostrea deltoidea. Plants.	Oolite. Turbinolia. Caryophyllia.
Terebratula lacunosa. Scyphiæ. Pentacr. cingulatus.	Clays and Calcareous Beds. A. polygyratus, flexuosus.	Facies à chaille.	Corallian.	Mya. Trigonia. Coral Rag Oolite.	Coral Rag Oolite. Cidaris. (*Heddington*, &c.)	Coral Rag. Astræa. Apiocrinus Milleri. Cidaris.
Laminated Limestones, with Am. planulati.	Clays, with Terebratula impressa.	A. biplex. Argovian Group. Spongites. Tereb. impressa.	Argovian Group. T. lacunosa. Spongia.	Ter. insignis. Cidaris. Hemicidaris.	Calcareous Grit.	Calcareous Grit. Am. perarmatus.

TABLE II.—The Brown

Franconia.	Swabia.	Switzerland and the Jura.
		Oxfordian Marls. Am. annularis, Lamberti, hecticus. Belemn. hastatus.
	Ornati Clay. Am. ornatus, Lamberti, hecticus, bipartitus, annularis. Clythia.	**Kellovian.** Am. macrocephalus, anceps, ornatus.
	Macrocephali Bed. **Clays.** Am. Parkinsoni. Trigonia costata. Ostrea costata.	**Cornbrash, or Whitish Oolite.**
Dark Coloured Clays. Am. macrocephalus, ornatus, Jason, Parkinsoni. Terebr. varians.	Brown Oolitic Clays. Terebratulæ. Am. bifurcatus. Bel. giganteus.	**Forest Marble.** Compact blue limestone. Corals.
Brown Marls. Belem. giganteus. Am. Humphriesianus. Tereb. perovalis, spinosa, Theodori.	**Clays and Calcareous Marls.** Am. coronatus, Humphresianus. Ostrea crista galli. Brown Clays. Cidaris spines.	**Great Oolite.** **Vesulian Marls.** Belem. giganteus. Cidaris spines. Nerinæa.
Brown Sandstones. Am. discus, Murchisonæ. Trochus undulatus.	**Blue Limestones.** Pecten demissus.	**Coral Limestone.** **Lædonian Limestone.**
Black Clays. Am. opalinus. Nucula Hammeri, claviformis. Bel. clavatus.	**Sandstones and Clays.** Am. Murchisonæ. Pecten personatus. Gryphæa calceola. **Opalinus Clays.** Am. opalinus. Nucula Hammeri. Trigonia navis.	**Ferruginous Oolite.** Am. Murchisonæ.

Jurassic Series in			
Burgundy.	**Normandy.**	**South-England.**	**North-England.**
Kellovian and Oxfordian. Limestone, with Am. annularis, cordatus. **Cornbrash** or Oolitic limestone.	**Dives Clays.** (Oxfordian.) Am. Jason, ornatus, Lamberti, sublævis. Gryphæa dilatata. **Kellovian.** Am. cordatus, caprinus, Lamberti. Black marls. Ostrea Marshii. Gervillia. Perna.	**Oxford Clay.** Am. caprinus, perarmatus, macrocephalus, sublævis. **Cornbrash.** Terebratulæ.	**Oxford Clay.** Am. Jason, Duncani, athleta. Astacus (Clythia). **Kelloways Rock.** **Cornbrash.** Galerites depressus. Clypeus. Pholadomya Murchisoni. Ostrea Marshii.
Forest Marble. Corals. **Great Oolite.** **Fuller's Earth Marls.** Gervillia. Pholadomya. **Inferior Oolite.** Am. Parkinsoni. Donax Alduini. **Entrochi Limestone.** Corals.	**Forest Marble.** Corals. Apiocrinites rotundus, Parkinsoni, &c. (Luc Oolite.) Terebr. digona, concinna. Corals. Hemicidaris. **Great Oolite.** (Caen Oolite.) **Bayeux Oolite.** Am. Parkinsoni, coronatus, Humphriesianus. Pleurotomaria. Trigonia costata. Ostrea Marshii. Terebratula, &c.	**Forest Marble.** Pentacrinus vulgaris. Corals. **Bradford Clay.** Apiocr. intermedius, rotundus, &c. Terebratula digona. **Great or Bath Oolite.** **Fuller's Earth.** Gervillia. Pinna. Ostrea acuminata.	**Upper Moorland Sandstone.** Monocotyledonous Plants. **Grey Limestone.** Am. Blagdeni. Trigonia costata. Perna quadrata. **Lower Moorland Sandstone.** Monocotyledonous Plants.
Ferruginous Oolite. Terebratula.		**Inferior Oolite.** Pecten personatus. (Marly Sandstone.)	

Table II.—The Brown Jurassic Series in

Franconia.	Swabia.	Switzerland and the Jura.	Burgundy.	Normandy.	South-England.	North-England.
Dark Coloured Clays. Am. macrocephalus, ornatus, Jason, Parkinsoni. Terebr. varians.	**Ornati Clay.** Am. ornatus, Lamberti, hecticus, bipartitus, annularis. Clythia. **Macrocephali Bed.** **Clays.** Am. Parkinsoni. Trigonia costata. Ostrea costata.	**Oxfordian Marls.** Am. annularis, Lamberti, hecticus. Belemn. hastatus. **Kellovian.** Am. macrocephalus, anceps, ornatus. **Cornbrash, or Whitish Oolite.**	**Kellovian and Oxfordian.** Limestone, with Am. annularis, cordatus. **Cornbrash** or Oolitic limestone.	**Dives Clays.** (Oxfordian.) Am. Jason, ornatus, Lamberti, sublævis. Gryphæa dilatata. **Kellovian.** Am. cordatus, caprinus, Lamberti. Black marls. Ostrea Marshii. Gervillia. Perna.	**Oxford Clay.** Am. caprinus, perarmatus, macrocephalus, sublævis. **Cornbrash.** Terebratulæ.	**Oxford Clay.** Am. Jason, Duncani, athleta. Astacus (Clythia). **Kelloways Rock.** **Cornbrash.** Galerites depressus. Clypeus. Pholadomya Murchisoni. Ostrea Marshii.
Brown Marls. Belem. giganteus. Am. Humphriesianus. Tereb. perovalis, spinosa, Theodori.	Brown Oolitic Clays. Terebratulæ. Am. bifurcatus. Bel. giganteus. **Clays and Calcareous Marls.** Am. coronatus, Humphresianus. Ostrea crista galli. Brown Clays. Cidaris spines. **Blue Limestones.** Pecten demissus.	**Forest Marble.** Compact blue limestone. Corals. **Great Oolite.** **Vesulian Marls.** Belem. giganteus. Cidaris spines. Nerinæa. **Coral Limestone.** **Lædonian Limestone.**	**Forest Marble.** Corals. **Great Oolite.** **Fuller's Earth Marls.** Gervillia. Pholadomya. **Inferior Oolite.** Am. Parkinsoni. Donax Alduini. **Entrochi Limestone.** Corals.	**Forest Marble.** Corals. Apiocrinites rotundus, Parkinsoni, &c. (Luc Oolite.) Terebr. digona, concinna. Corals. Hemicidaris. **Great Oolite.** (Caen Oolite.) **Bayeux Oolite.** Am. Parkinsoni, coronatus, Humphriesianus. Pleurotomaria. Trigonia costata. Ostrea Marshii. Terebratula, &c.	**Forest Marble.** Pentacrinus vulgaris. Corals. **Bradford Clay.** Apiocr. intermedius, rotundus, &c. Terebratula digona. **Great or Bath Oolite.** **Fuller's Earth.** Gervillia. Pinna. Ostrea acuminata.	**Upper Moorland Sandstone.** Monocotyledonous Plants. **Grey Limestone.** Am. Blagdeni. Trigonia costata. Perna quadrata. **Lower Moorland Sandstone.** Monocotyledonous Plants.
Brown Sandstones. Am. discus, Murchisonæ. Trochus undulatus. **Black Clays.** Am. opalinus. Nucula Hammeri, claviformis. Bel. clavatus.	**Sandstones and Clays.** Am. Murchisonæ. Pecten personatus. Gryphæa calceola. **Opalinus Clays.** Am. opalinus. Nucula Hammeri. Trigonia navis.	**Ferruginous Oolite.** Am. Murchisonæ.	**Ferruginous Oolite.** Terebratula.		**Inferior Oolite.** Pecten personatus. (Marly Sandstone.)	

Table III.—The Black

Franconia.	Swabia.	Switzerland and the Jura.
	Jurensis Marl. A. radians, Jurensis, insignis. **Posidonomya Schists.** Saurii. Pisces. Loligo. Am. depressus, Lythensis, annulatus. Belemnites acuarius. Pentacrinus subangularis. Am. costatus. Terebratula digona. Belemnites paxillosus. **Amaltheus Clays.**	**Superliassic Grit.** Asterias. **Superior Lias. Trochus Marls.** Am. communis, radians, insignis, Jurensis, Germaini, sternalis. **Bituminous Schists.**
Clays. Am. hircinus, radians, Jurensis. Bel. digitalis, acuarius. **Posidonomya Schists.** Saurii. Pisces. Avicula substriata. Am. subarmatus, heterophyllus.	A. Davæi, lineatus. Belemnite-bed. **Numismalis Clays.** Am. Taylori, Jamesoni.	**Plicatulæ Marls.** **Marls with Am. margaritatus.** Am. Davæi. **Grey Marls with Belemnites.** Terebratula numismalis.
Blue Clays. Am. costatus.	Am. raricostatus. Am. oxynotus, et bifer. Pholadomya-bed. Am. Brookii. T. vicinalis. **Turneri Clays.** Am. Turneri.	**Cymbium Beds.** Mactromya gibbosa. Am. raricostatus, oxynotus, bifer, natrix.
Aschach Limestones. A. natrix, ibex. Terebratula vicinalis.	Pentacrinus basaltiformis. Am. Bucklandi. Gryphæa arcuata. **Arietes Beds.**	Pentacrinus. Am. Bucklandi. **Limestone with Gryphæa arcuata.**
Hard, coarsely crystallized Sandstones.	**Sandstones.** Am. angulatus. **Thalassites Bed.** Thalassites concinnus. Am. psilonotus.	**Cardinia Bed.** Cardinia concinna, securiformis.
Keuper.	**Keuper.**	**Keuper.**

Jurassic Series in

Burgundy.	Normandy.	South-England.	North-England.
Superliassic Grits. Trochus-marls. Ammon. bifrons, radians. Vassy Cement Bed. Saurii. Pisces. Am. heterophyllus, annulatus.			Whitby Shale. Posidonomya. Inoceramus. Am. Walcottii, annulatus, subarmatus, heterophyllus. Nucula ovum.
Cymbium Limestone. Gryphæa gigantea. Am. amaltheus. Pecten æquivalvis. T. digona, lagenalis. Am. Davæi.		Alum Shale. (*Lyme Regis.*) Saurii. Am. Walcottii, heterophyllus. Jet Rock.	Banbury Sandstone. Belemnites penicillatus. Edgehill Sandstone. (Ferruginous.) Amphiura. Mya. Unio.
Belemnite Marls. T. rimosa, numismalis.	Am. communis, Thouarsensis, Holandrei, bifrons. Fish of Croissilles.	Marlstone. Am. Stokesii. Gryph. Maccullochii.	Downcliff Sandy Marl. Am. armatus, Taylori. Aberthan Blue Marl. Am. oxynotus, bifer.
A. Brookii. T. vicinalis. Limestone with Gryphææ and Am. Bucklandi.	Gryph. gigantea. T. lagenalis, quadrifida. Am. margaritatus, heterophyllus. Spirifer. Euomphalus. Conus. Am. Jamesoni, Davæi.	Am. Bucklandi. Lias. Am. angulatus. Lima Hermanni. Pachyodon concinnus, hybridus.	Am. Bucklandi, Conybeari, &c. (*Rugby*).
Sinemurian Group. Cardinia.	Inferior Lias. Cardinia.		Linksfield Sandstone.
Arkose & Granite.	Trilobite Sandstone.	New Red Sandstone.	

Table III.—The Black Jurassic Series in

Franconia.	Swabia.	Switzerland and the Jura.	Burgundy.	Normandy.	South-England.	North-England.
Clays. Am. hircinus, radians, Jurensis. Bel. digitalis, acuarius. **Posidonomya Schists.** Saurii. Pisces. Avicula substriata. Am. subarmatus, heterophyllus.	**Jurensis Marl.** A. radians, Jurensis, insignis. **Posidonomya Schists.** Saurii. Pisces. Loligo. Am. depressus, Lythensis, annulatus. Belemnites acuarius. Pentacrinus subangularis. Am. costatus. Terebratula digona. Belemnites paxillosus. **Amaltheus Clays.**	**Superliassic Grit.** Asterias. **Superior Lias. Trochus Marls.** Am. communis, radians, insignis, Jurensis, Germaini, sternalis. **Bituminous Schists.**	**Superliassic Grits.** Trochus-marls. Ammon. bifrons, radians. **Fassy Cement Bed.** Saurii. Pisces. Am. heterophyllus, annulatus.	Am. communis, Thouarsensis, Holandrei, bifrons. Fish of Croissilles.	**Alum Shale.** (*Lyme Regis.*) Saurii. Am. Walcottii, heterophyllus. **Jet Rock.**	**Whitby Shale.** Posidonomya. Inoceramus. Am. Walcottii, annulatus, subarmatus, heterophyllus. Nucula ovum.
Blue Clays. Am. costatus. **Aschach Limestones.** A. natrix, ibex. Terebratula vicinalis.	A. Davæi, lineatus. Belemnite-bed. **Numismalis Clays.** Am. Taylori, Jamesoni.	**Plicatulæ Marls.** **Marls with Am. margaritatus.** Am. Davæi. **Grey Marls with Belemnites.** Terebratula numismalis. **Cymbium Beds.** Mactromya gibbosa. Am. raricostatus, oxynotus, bifer, natrix.	**Cymbium Limestone.** Gryphæa gigantea. Am. amaltheus. Pecten æquivalvis. T. digona, lagenalis. Am. Davæi. **Belemnite Marls.** T. rimosa, numismalis.	Gryph. gigantea. T. lagenalis, quadrifida. Am. margaritatus, heterophyllus. Spirifer. Euomphalus. Conus. Am. Jamesoni, Davæi.	**Marlstone.** Am. Stokesii. Gryph. Maccullochii.	**Banbury Sandstone.** Belemnites penicillatus. **Edgehill Sandstone.** (Ferruginous.) Amphiura. Mya. Unio. **Downcliff Sandy Marl.** Am. armatus, Taylori. **Aberthan Blue Marl.** Am. oxynotus, bifer.
Hard, coarsely crystallized Sandstones.	Am. raricostatus. Am. oxynotus, et bifer. Pholadomya-bed. Am. Brookii. T. vicinalis. **Turneri Clays.** Am. Turneri. Pentacrinus basaltiformis. Am. Bucklandi. Gryphæa arcuata. **Arietes Beds.** **Sandstones.** Am. angulatus. **Thalassites Bed.** Thalassites concinnus. Am. psilonotus.	Pentacrinus. Am. Bucklandi. **Limestone with Gryphæa arcuata.** **Cardinia Bed.** Cardinia concinna, securiformis.	A. Brookii. T. vicinalis. **Limestone with Gryphææ and Am. Bucklandi.** **Sinemurian Group.** Cardinia.	**Inferior Lias.** Cardinia.	Am. Bucklandi. **Lias.** Am. angulatus. Lima Hermanni. Pachyodon concinnus, hybridus.	Am. Bucklandi, Conybeari, &c. (*Rugby*). **Linksfield Sandstone.**
Keuper.	**Keuper.**	**Keuper.**	**Arkose & Granite.**	**Trilobite Sandstone.**	**New Red Sandstone.**	

On the JURA-FORMATION *of* RUSSIA. By Herr EICHWALD.

[Leonhard u. Bronn's Jahrbuch f. Min. u.s.w. 1850, pp. 225-227; and Erman's Archiv, vi. 378, *et seq.*]

THE "Jura" is found in several districts, but with the exception of the Crimea and Caucasus, it forms no mountain-chain. In 1830, the author examined the first Jurassic beds near the Popilani on the Windau, in the government of Wilna, and since that time they have been also traced in the interior of Russia. In the Indet-system they contain much argillaceous iron-stone, and in the system of the Sandomir-formation they are characterized by white sandstone. The organic remains contained in the latter differ very much from those in the "Jura" at Popilani. There are *Serpula lineata, S. articulata, Asterias Jurensis, Pentacrinus basaltiformis, Terebrat. varians, T. Rogerana, Gryphæa dilatata, Gervillia aviculoides, Panopæa Murchisonæ, Isocardia corculum, Astarte Voltzi, Lyriodon navis,* many *Pleurotomariæ, Belemnites,* and *Ammonites.* These beds are covered with a black and brown, micaceous and very soft loam, which at some places passes into potter's clay. Distant from this small Jurassic basin, we find eastward another large one, in the middle of Russia, in the centre of which Moscow is situated; and from hence the Jurassic strata extend into the governments of Rjasan, Vladimir, Nijni Novgorod, Tambf, and Simbirsk. This basin is separated from another, which covers the northern declivity of the Obschey Sirt, and is chiefly developed in Orenburg, near Ilezkaja, here forming the banks of the Ilek and the Ural. Besides this there is another large northern Jurassic basin which extends through the governments of Kostroma and Wologda, towards that of Archangel, where the Jurassic beds occupy the Timan hills, and end at the shore of the Frozen Ocean. Parallel with this runs another chain to the east of the Ural mountains, along the rivers Soswa and Tolga.

Thus, almost everywhere in Russia we find "Jura"-basins, and these contain more or less different forms of marine animals. The rocks mostly consist of dark pyritous schists, of sand [?] and sandstone, of marl, and less frequently, however, of limestone, in which, as in England, large nodules of marly limestone are often found. These Jurassic beds everywhere represent the Middle or Oxfordian formations of England; only here and there appear beds that are similar to the Lias, as for instance those in the government of Moscow and Simbirsk, which contain bones of *Ichthyosaurus* and *Plesiosaurus* of very large size. Only at Petrowsk, near the boundary of the government of Charkow, are the upper developed together with the middle Jurassic beds; and here they form a small isolated basin.

The "Jura"-formation around Moscow has been most minutely examined. Here it takes its place immediately upon the mountain limestone. The strata are of calcareous marl, which at some places passes into ferruginous marly loam with small grains of Linsenerz [?] [Pea-ore—octahedral arseniate of copper], as near the villages of Miatschkovo and Grigorjew. At other places the compact limestone itself contains the Linsenerz, and at the same time crystals of iron-pyrites. Thus the ferruginous loam passes sometimes into ferruginous oolite, which only rarely contains fossils, as for instance *Belemnites Panderanus*, d'Orb. Upon this loam lies a black or grey calcareous loam, micaceous, and very similar to lias, containing besides *Am. alternans* and *Belemn. absolutus*, *vertebræ* of *Ichthyosaurus platyodon* and *Plesiosaurus Frearsii.* The shaly clay of Medjansk for the most part resembles lias; it is so black and bituminous that it was formerly mistaken for a coal-formation. A similar liassic loam is found near Simbirsk. This loam appears at many places in the government of Moscow, and upon it reposes a sandy marl, coarse-grained, shaly, and black, containing mica-flakes and gypsum; it alternates with a black loam, containing many nodules of argillaceous ironstone. All these beds abound with organic remains, as *Cidaris gemmifer*, *Dentalium gladiolus*, *Terebrat. Fischerana*, *T. aptycha*, *T. oxyoptycha*, *Avicula* (*Aucella*) *Fischerana*, *Pecten lens*, *P. demissus*, *Astarte*, *Arca*, *Lyriodon*, *Orbicula Mæotis*, a Turrilite-like *Scyphia ventricosa*, numerous *Ammonites*, and a few Shark-teeth. The Jurassic beds in the government of Simbirsk are, from Jasykow's researches, as well known as those of the northern Ural, on the Lobesina and Tolga. In the latter many large *Ammonites* chiefly occur, as *Am. borealis*, above a foot and a half in diameter, *Am. Königi*, *Am. Sagitta*, *Am. polyplocus*, *Am. septentrionalis*, also *Belemn. curtus* (*Russiensis*, d'Orb.), *B. mammillaris*, *Pleurotomaria septentrionalis*, *Pholadomya angustata*, *Ph. monticola*, and several others; *Panopæa antiqua*, *Astarte Veneris*, *Cucullæa Vogulica*, many *Pinnæ*, and other species, but chiefly *Terebratulæ* in great quantities. The Jurassic beds also of Ilezkaja and Obschey Sirt in the south of the Ural are remarkable for their fossils. The Great Balchan, on the eastern coast of the Caspian Sea, consists in its upper portion of Jurassic strata. The "Jura"-formations of the Caucasus and the Crimea are rich in Corals and Crinoidea, which are not found in the more northerly Jurassic basins. The "Jura"-formations in northern Asia near the rivers Jenisei and Lena, are less known. Lastly, according to the author, the "Jura" is present in New Siberia.

[T. R. J.]

On some OUTLIERS *of the* ALPS *west of* NEUSTADT *and* NEUNKIRCHEN. By FR. VON HAUER.

[Haidinger's Berichte, Band vi. p. 10.]

HERR VON HAUER communicated the results of some geological investigations made in the spring of 1849, first in the company of Dr. Hörnes and subsequently in that of HH. Morlot and Czjzek, among the outliers of the Alps west of Neustadt and Neunkirchen; in order to ascertain whether, as has been frequently asserted, *Nummulites* really occur mixed with the chalk fossils of the Gosau formation.

The first spot visited was the declivity of the Gahnsberg, northwest of Gloggnitz. The neighbourhood of what is called the Poschenhaus and of Gahnsbauer had been pointed out as very important by Herr Partsch.

That gentleman had lately visited this spot, and most obligingly lent them the map of the Quarter-master-general's staff, which he had employed on his route, and which contains a vast quantity of original unpublished observations. From Gloggnitz the road leads over St. Christoph behind the Grillenberg up to the steep declivity of the Johannsberg. Traces of fossils are soon observed, which are most numerous south of the Gahnsbauer, a house lately burnt down. Here there is a small plateau with very steep sides towards the valley, throughout which the rock is everywhere observable, although much overgrown with trees. The most important organic remains are the following :—

Gryphæa Columba, Lam.

Ostræa serrata, Defr.

Hemipneuster radiatus, Agass. Only the flat under side with small fragments of the sides are preserved. The very distinct channels running down from the apex to the mouth, as well as the general appearance, seem to make this identification certain.

Inoceramus; in small fragments. The determination of this genus rests upon the fibrous structure of the fractured surface.

Terebratula; several species, not determinable.

Hippurites; a fragment, not determinable.

Ostræa, or *Gryphæa*; fragments of a large species, not determinable.

Together with these species, and sometimes in the same hand specimens, occur numbers of lenticular bodies, which bear so close a resemblance to *Nummulites*, that they were only distinguished by a close examination in the cabinet. The interior does not exhibit the regular spirally-arranged chambers of *Nummulites*, but cells irregularly or at least not spirally disposed, exactly as in the *Lycophris* of the chalk tuff of St. Peter's Mountain, near Maestricht. Some naturalists, it is true, have united the *Nummulites* with *Lycophris* and *Orbitulites** [*Orbitoides*?]; yet the want of a spiral arrangement of the cells in the two latter seems to afford a good character on which to found a separation. The *Lycophris* of Gahnsbauer sometimes exceed an inch in diameter; they occur in the rock in precisely the same abundance as *Nummulites* do, and might therefore readily cause these beds of the age of the chalk to be confounded with the eocene nummulitic formations.

The above fossils are found in a reddish calcareous sandstone, which on being dissolved in an acid leaves a considerable residue of quartzose sand.

Though well-exhibited to great heights, no traces of bedding can be seen in it.

Opposite the Gahnsbauer, N.E. of Prüglitz, a second locality where the Orbitulite sandstone shows itself, was examined. Here, as far as the eye could judge, it rose to the same height above the valley as at

* [With regard to the true foraminiferous character of this genus and that of *Orbitoides*, with which possibly it is here confounded, and their relations to *Nummulites*, see Dr. Carpenter's Paper on the Structure of *Nummulites*, *Orbitolites*, and *Orbitoides*, Quart. Journn. Geol. Soc. vol. vi. p. 21 *et seq.*—Ed.]

Gahnsbauer, with the same mineral character and containing fragments of *Inoceramus*.

A road leads from Prüglitz by a pass called the Hals, through Breitensol near Rohrbach to Buchberg. This road proved most interesting, not only from the picturesque beauty of the scene, but from the important geological discoveries which were made along it. Breitensol lies in a pleasing valley of no great extent, formed of beds of the Gosau formation and surrounded by high hills. Immediately to the south, at a distance of scarce a hundred paces, a marly sandstone is seen in several quarries containing abundance of *Orbitulites*, as on the declivity of the Gahnsberg. With them occur—

Pectunculus, n. sp. This species is the same which occurs frequently in the marls of the Gosau formation of Muthmansdorff, in the district called the New World [neue Welt], to the westward of Neustadt.

Turritella, sp. ?—with other Gosau fossils.

North of Breitensol the valley widens out, and on its eastern side, opposite to the Schacherberg, very interesting fossils are found in great quantities in the loose stones which have been collected for building purposes. Among them are large and beautiful specimens of a *Gryphæa*, probably identical with *G. vesicularis*.

Pecten, n. sp., very like the *P. latissimus* of the Leitha limestone, but distinguishable by sharper and more numerous tubercles on the ribs. The same species is found in the Gosau formation N. of Grünbach.

Pectunculus, n. sp., same as that before noticed.

Inoceramus, large and well-preserved; agreeing with those of the Gosau formation.

Orbitulites have not been found here, and their absence seems to be connected with the change in the mineralogical condition of the rock, which here is not sandy, but resembles the common Gosau marls.

Farther to the north of Breitensol, a ravine, which is partly artificial, leads into the valley of the stream which flows by Rohrbach. The rocks, which at a distance closely resemble the Alpine limestone, and form equally abrupt precipices, prove under the hammer to be a coarse conglomerate.

At Buchberg a projecting headland of black limestone with veins of white calcareous spar appears. This belongs to the older Alpine limestone, as may be ascertained by examining the narrow ravine which leads from Pfennigbach to Ratzenberg. Regular beds of this limestone are here overlaid by an equal thickness of red and green shales, which contain the *Myacites fassaensis*, and other bivalves of the "red shale of Werfen." The whole system of these shales is most distinctly seen in the bed of the stream which flows through Pfennigbach; its strike is E. and W. with a northern dip. Farther on in the same ravine great masses of the black limestone are seen, extending to the plateau of Ratzenberg, which is composed of the coal-bearing beds of the Gosau formation. North of Ratzenberg this plateau sinks, and farther down on the road to Vorau a gallery has been driven, on whose sides the same black limestone is seen, with the red shales reposing on it, but containing few fossils. Thus the Gosau beds lie immediately on the shales which are of the age of the "bunter sandstein," and on the black limestone which is still older. Farther on in the direction of the village of Grünbach, conglomerate is first found, and soon after the Gosau marls with *Inocerami*, which continue all the way to Grünbach. The relation of the conglomerate to the other beds unfortunately could not be ascertained.

About a mile north of Grünbach, some very abrupt and pointed hills rise, of a remarkably bright yellow colour. These consist of a calcareous sandstone, in all respects similar to that of the Gahnsbauer, only somewhat brighter coloured. It is loaded with innumerable *Orbitulites*, which at first sight one is disposed to take for *Nummulites*. Fragments of *Inocerami*, of large *Ostrææ* or *Gryphææ* (possibly *Gryphæa vesiculosa*), of *Hippurites*, with a cast of *Lyriodon aliforme*, were found in it, together with pebbles of the grey Alpine limestone. In these abrupt hills also, although well-exposed to a great height, scarce any stratification can be detected. In one solitary spot, an east and west strike with a northern dip seems to be made out, which would agree with the general strike of the Gosau marls near Grünbach. If so, from this position of the Orbitulite sandstones, which occupy the highest positions and are surrounded by the Gosau marls, the conclusion is, that the sandstones are the newer. Still further north, on the declivity of the 'Vorderwand,' lie thick beds containing *Hippurites*, mostly belonging to the species *H. costulatus*, Goldf. Splendid specimens, with both valves well-preserved, are met with, and along with them *Caprina paradoxa*, Math. (*C. Partschii*, Hau.), *Tornatella Lamarckii*, Goldf., and a large undescribed *Astræa*.

South of Grünbach, on the left of the road opposite Rosenthal, the doubtful conglomerate is again met with; and then, at the place last mentioned, the red shales with *Myacites Fassaensis*, which continue all the way to Schrattenbach. Here the Alpine limestone comes up, and composes the hill on which Schrattenstein stands.

The same Alpine limestone continues along the road from Stinenstein to Flatz on the Gesingberg. In the ravine which leads down from the heights opposite Flatz, a considerable thickness of the shales of the "bunter sandstein" formation occurs.

Immediately north of Lorenzen, a group of low flattened limestone hills rise, which are separated from the mass of the Kettenloizberg by an intervening valley, and are remarkable even at a distance for their red colour. They consist of a red, sometimes arenaceous limestone, and contain, especially on their south-western flank, vast numbers of plicated *Terebratulæ*, which have not yet been identified. Their general appearance reminds one of the *T. concinna* of the Jura formation. Few other fossils occur with them, but we may mention a well-preserved valve of a smooth *Pecten*. On the top of this formation lies an extensive plateau of rock, from which the *Terebratulæ* have entirely disappeared; on the weathered surface, however, vast numbers of organic forms are seen, though seldom distinct enough to allow of determination. Small corals are the most abundant, and on one specimen a very distinct transverse section of an *Orbitulites*. Hence it would follow that these limestones and calcareous sandstones belong to the same Orbitulite formation as the rocks of the Gahnsbauer. What adds to this probability is that a fragment of a large *Ostræa* or *Gryphæa* has been obtained from the south-east declivity of these hills, opposite Lorenzen, which well agrees with one of the species before mentioned. On these hills also no distinct stratification can be observed.

Descending these hills by their western declivity, on reaching the plain the Leitha conglomerate is met with, which continues all the way to Neunkirchen.

The same conglomerate occurs on the road from Neunkirchen to Ragletz; but as soon as the declivity of the range north-west of that place is reached, the Orbitulite sandstone comes in, and higher up gives place to the Alpine limestone. Still further north, to the south-west of Hettmansdorff, there were found in Orbitulite sandstone well-preserved specimens of crabs' claws, which exactly correspond with the claws of *Calianassa* (*Pagurus*) *Faujasii* from St. Peter's Mountain near Maestricht. Some specimens appear rather to resemble the *C. antiqua*, Otto, from the extremities being somewhat straighter and longer, but probably are mere varieties of the first-named species. With the crabs' claws occur fragments of *Inocerami*, of *Echinoderms*, and several species of *Terebratulæ*.

The Orbitulite sandstone continues all the way from hence to Strelzhof in a north-west direction, fringing the older mountains, and only interrupted by the valleys which intersect it. Betwixt Willendorf and Strelzhof it becomes more marly; the *Orbitulites* are less abundant, and are replaced by the fossils peculiar to Gosau. *Pecten striato-costatus*, *Fungiæ*, and entire *Inocerami* were found in abundance, and the claws of the *Calianassa* were also present.

Finally, on the north-east side of the Kehnberg, the Orbitulite sandstones attain a very considerable height, beyond which they were not observed.

Imperfect as the preceding observations are, and leading as they do to the expectation that further inquiries in these interesting localities will bring to light many new facts, still some general conclusions may be deduced from them:—

1. True *Nummulites* are not met with in the country examined mixed with chalk fossils: they are absolutely wanting; and all former notices of their occurrence rest on the circumstance that they have been confounded with *Orbitulites* [*Orbitoides*?], fossils of a different though similar structure.

2. The rocks containing the *Orbitulites* [*Orbitoides*?] are closely connected with the Gosau beds, and in fact form their highest division; their fossils prove them to be on the same parallel with the chalk tuff of St. Peter's Mountain near Maestricht, that is to say, the highest member of the chalk formation.

The so-called Nummulite beds of Neuberg in Steiermark also belong to the same Orbitulite formation. The lenticular bodies which they contain are *Orbitulites* [*Orbitoides*?], and the rest of their fossils are fragments of *Inocerami*, large *Ostrææ*, &c., which, together with the geographic position of the beds, agree perfectly with the rocks of the Gahnsbauer.

It has not been in the power of the authors to compare the *Nummulites* so often cited as occurring in the Gosau beds. The Vienna collection does not contain any specimens; but perhaps it would not be too hazardous to conjecture, that in that case also *Nummulites* have been confounded with *Orbitulites* [*Orbitoides*?], and that in the Eastern Alps *Nummulites* are not found in the chalk formation.

[J. C. M.]

On the Presence of ALKALIES *and* PHOSPHORIC ACID *in some* LIMESTONES. By Herr FEHLING.

[Würtemb. naturw. Jahresb. t. v. p. 72 *et seq.*; and Leonhard u. Bronn's Jahrb. f. Min. 1850, p. 445.]

THE results of the researches made by Faist agree on the whole with those obtained by Schramm; in all limestones alkalies were found to be present, combined either with hydrochloric, or for the most part with carbonic acid. Ten limestones gave decided and often very strong evidence of the presence of phosphoric acid :—Jura-limestone from Unterkochen and from Hundersingen; Dolomite from Jaxtfeld (uppermost bed of the Friedrichsthal limestone); Lias-limestone from Rohr near Vaihingen; Jura-marl from the Geisslinger Steige (above the first *Spongites*-bed); Keuper-limestone from the Weinsteige; *Amalthei*-clay from Jesingen near Kirchheim; upper *Posidonomyæ*-schist from Ohmden; argillaceous Limestone from Blaubeuren; and argillaceous Muschelkalk from Zuffenhausen. There was no phosphoric acid reaction in the Diluvial-limestone of Cannstatt, the Lias-marl of Vaihingen, and the Carrara marble. [T. R. J.]

On the IDENTITY *of* ARKANSITE *and* BROOKITE. By C. RAMMELSBERG.

[Poggend. Annal. d. Phys. t. lxxvii. p. 586 *et seq.*; and Leonhard u. Bronn's Jahrb. f. Min. 1850, p. 453.]

DR. C. U. SHEPARD some years since gave the first account of Arkansite, discovered at Magnet Cove, Hot Springs County, Arkansas*. According to the author, the crystals of the mineral examined by him quite agree externally with Dr. Shepard's description. The specific gravity† he found to be=3·892, 3·923, 3·949, and in a chemical analysis the Arkansite behaved as pure titanic acid.

The forms of the substance are the same as those of Brookite, although the planes are somewhat different. [T. R. J.]

* Silliman's American Journal, New Ser. vol. ii. p. 249; and vol. iv. p. 279.

† [Dr. Shepard gives 3·854 as the spec. grav.—ED.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Anthracite Plants *of the* Alps.
By Professor Oswald Heer.

[Leonhard und Bronn's Neues Jahrbuch für Mineral. u. s. w. 1850, pp. 657–674; Mittheil. der Nat. Gesellsch. in Zurich, 1850; and Abstract, Biblioth. Univ. Genève, March, 1851.]

When Adolphe Brongniart, twenty-two years ago, described the anthracitic plants of the Tarentaise*, he referred them to the Lias, on the authority of Élie de Beaumont, and endeavoured by an ingenious hypothesis to explain the remarkable fact, that these plants without exception agreed, not only generically but specifically, with those of the Coal-measures. Brongniart has since retracted this opinion, which was completely refuted by Favre†; and he now considers these anthracitic plants‡ as belonging to the Carboniferous flora, which is the view taken by Unger, Bunbury, and all the botanists who have studied the matter. The geologists are divided in opinion. E. de Beaumont and Sismonda adhere to the original view, which is, that the anthracitic and belemnitic schists belong to one formation, viz. the Lias; and Murchison has lately adopted this view§; so that it is supported by the highest authorities.

On the other hand, Favre has pointed out|| that the Anthracite of La Mure in the Isère Department *underlies* the Lias, which is the reverse of the case in the Tarentaise, where the beds, he asserts, have acquired their present position by folding. This also is the opinion of A. Escher von der Linth. These geologists believe that an inversion of the strata has taken place in Petit-Cœur, so as to bring the bed with Belemnites under the plant-beds. The point is of great interest; since not only the question, whether the entire Carboniferous system is wanting in the Alps, depends upon it; but also whether the results arising from the study of the fossil flora entitle us to come to conclusions as to the history of the development of the vegetable creation**. For we cannot conceal from ourselves, that if the anthra-

* Annal. des Sciences Nat. 1828, p. 113.

† Sur les Anthracites des Alpes, Mém. Soc. Phys. Genève, tom. ix. p. 418.

‡ Comp. Annal. des Scien. Nat. 1849, p. 298.

§ On the Structure of the Alps, Apennines, and Carpathians, Quart. Journ. Geol. Soc. 1848, vol. v. pp. 175 *et seq.* [See Sir R. I. Murchison's further observations on the Petit-Cœur Section, *Ibid.* vol. vi. p. 382, note.—Ed.]

|| *Loc. cit.* p. 423.

** [See Anniv. Address, *supra* (No. 26), pp. xliii *et seq.*—Ed.]

citic plants are to be united to the Liassic flora, we must abandon some of the most important results hitherto obtained. Every contribution which may aid in clearing up these relations is of value. This induces me to offer a list of the specimens, collected by Dr. A. Escher von der Linth and Professor Merian in the Valais and in the Tarentaise, and preserved in the Museums of Zurich and Basle, which I have lately re-examined and compared with Coal-plants. I have first a few general observations to offer.

The question to be considered is this:—Do the belemnite- and the plant-beds belong to the same formation or not? If the former be true, the question arises,—Is that formation to be regarded as Coal from its plants, or as Lias from its Belemnites? Brongniart, Bunbury, and Chamouset declare themselves of the first opinion, seeing that the Belemnites are not specifically distinguishable, and that it is by no means proved that the undoubted Lias beds containing Ammonites belong to the Belemnitiferous series. E. de Beaumont, Sismonda, and Murchison take the latter view, since Belemnites have never been found below the Lias, and because they think these beds are inseparable from the ammonitic strata. These geologists found their main argument on the position of the beds at Petit-Cœur. Here the dark calcareous flags with the Belemnites repose on talcose schists, and are in their turn covered by the schists containing the plants. The belemnitic and anthracitic beds, says Murchison*, form parts of the same group, the upper and lower members being identical in composition; and the talcose schists and the sandstones being repeated. But this does not seem to me conclusive. In other parts of the Alps, as in the Valais and the Col de Balme, the calcareous and the plant-bearing strata are seen to be separate, the latter lying immediately on crystalline rocks: and even at Petit-Cœur the belemnite- and plant-beds cannot possibly belong to one another. Belemnites are acknowledged to have been marine animals, and they must have been deposited on a sea-bottom. But neither in the Tarentaise, in Savoy, in the Valais, nor in Styria, do the plant-bearing schists contain the slightest trace of marine animals or marine vegetation†. The plants are all land-plants, and consequently, at the time of their deposition, dry land must have been in the vicinity. So perfect is the state of their preservation,—the most delicate pinnæ being still connected together, the tender *Annulariæ* and *Asterophyllites* still with their perfect whorls of leaves united to their slender stalks, the margins of the leaves seldom torn or damaged, and the leaves so accurately spread out on the rock as if they were painted on it,—that it is incredible that they can have been transported far. They must therefore have grown in the neighbourhood. Let us suppose that they grew on the margin of a sea in which Belemnites lived,

* *Loc. cit.* p. 176.

† The *Annulariæ* and *Asterophyllites* alone are looked on by some (although I think incorrectly) as aquatic plants; still not as *marine* plants. These plants, especially the *Annularia fertilis*, occur abundantly with and under the Ferns: they probably lived in company with them under the shadow of tall trees, as do the *Asperulæ* of the present time, to which they bear great resemblance.

and were washed into it. If so, they ought to be found mixed with marine remains, which is not the case: no Belemnite or other marine animal has ever been found in any of the plant-beds, and *vice versâ*: moreover, at Petit-Cœur a mass of sandstones containing no organic remains occurs between the two deposits. The probability is that the anthracitic plants were not deposited in salt water, since in that case Fucoids ought to be mixed with them; as happens at Radoboj, where insects and land-plants are mixed with marine remains, and at the Col de Madelaine, where Escher found fucoidal plants in the belemnitic schist. Since then the belemnite-bed contains both marine animals and marine plants, while the anthracite-bed has no trace of either, I am entitled to infer that the latter was accumulated in fresh water; which sufficiently explains the absence of Carboniferous forms of animals; since both the *Mollusca* and the characteristic *Trilobites* of that period were marine. Their absence is no objection to the referring the anthracitic plants to the Coal flora, but merely proves that the plant-beds are a totally different group from the belemnite-beds. If the one be a marine and the other a fresh-water formation, a great 'hiatus' must occur between the two: at all events, it is clear from the complete difference of their organic contents that they cannot be considered as one formation; for organic characters, when so distinctly marked as in this case, are of far greater weight than petrographic characters. I am therefore of opinion, that at Petit-Cœur an inversion of the strata has taken place, which has thrown the belemnitic under the anthracitic beds. And if at Petit-Cœur, where the relations of the strata are most complicated, the circumstance of the sharp distinction between the organic contents of the two proves that they cannot be contemporaneous; still more evident is this in other parts of the Alpine chain, as in Provence, in the Valais, and in the Austrian Alps, where the anthracitic beds are seen to repose immediately on crystalline schists.

When we compare these plants with those of other formations, we readily find that they agree with those of the Carboniferous flora. The following list shows that our collections contain twenty-eight species, twelve of which have not yet been found in any other locality. If to these we add the species described by Brongniart and Bunbury*, we have in all forty-eight species. Of these, five seem never to have been found elsewhere, and to be peculiar to the anthracitic schists: viz. *Pecopteris Beaumontii*†, Brong., *P. pulchra*, Heer, *Neuropteris Soretii*, Brong., *N. Escheri*, Heer, and *Lepidophyllum caricinum*, Heer. About six species are doubtful, yet so closely resembling coal-plants, that they probably will be found to agree, when better specimens shall have been procured. Thirty-seven are identical with coal-plants, and not a single one agrees with any Triassic or Liassic plant.

If we compare these plants with those of the different divisions of the Coal-formation, we find that the greater part agree with those of

* [Quart. Journ. Geol. Soc. 1849, vol. v. pp. 138 *et seq.*—Ed.]

† [See observations on the apparent alliance of *P. Beaumontii* with *P. Whitbiensis*, *supra*, Part I. p. 194.—Ed.]

the oldest beds. *Calamites cannæformis*, Schl., and *Neuropteris Loshii*, Br., even appear in the Transition strata; and *Cyatheites Schlotheimi*, St. sp., one of the most abundant species in the anthracitic schists, together with *Neuropteris tenuifolia*, Schl. sp., or species closely resembling these two, according to Bunbury and Sharpe, are even found in the Silurian formation of Oporto*. *Stigmaria*, *Lepidodendra*, and the *Odontopteris Brardii*, Br., abound principally in the lower Coal-beds, and also occur in the anthracitic schists.

This anthracitic formation is widely extended: we find it not only in the South of France, in Savoy, and in the Valais; but Escher has also detected it in Engelberg and at Tödi, in Canton Glarus; and it may probably be traced to the Austrian Alps. Long ago it was found on the borders of Styria, Salzburg, and Carinthia, between Gmünd and Turrach; and lately M. von Morlot has discovered it in Carniola. The researches of Unger (upon an ancient plant-bed on the Stang-Alp in Styria, 1843) prove incontestably, that the anthracite of the Austrian Alps is contemporaneous with ours. There also the dark, plant-bearing schists repose on talc-slate and gneiss, and contain numerous land-plants, without the slightest trace of marine animals or vegetation. Of the forty-four species which Unger has described from thence, thirteen are identical with species in our anthracitic beds: of the remaining thirty-one, twenty-eight are true Carboniferous plants; and as twelve of the thirteen which are identical with ours are also known Carboniferous plants, there are in all forty true coal-plants in the Styrian anthracites. Among these we have five *Calamites*, *Stigmaria ficoides*, St. sp., *Annularia fertilis*, St., thirteen species of *Sigillaria*, and four of *Lepidodendron*, with the exception of *Sigillaria parallela*, Ung. (which seems peculiar to the locality); all are species found in the Coal of Europe and partly also of North America, and are looked on as forms characteristic of that formation.

Thus we have in the anthracites of Styria and the Eastern Alps seventy-nine species in all, of which only eight are peculiar to it, and about seven are doubtful; while sixty-four distinctly agree with true Coal-plants. This agreement holds not only when we compare the united flora of the anthracites with Coal, but also when that of the separate localities is compared with the Carboniferous flora: thus, for instance, the majority of the plants found at Petit-Cœur agree on the one hand with those of the other localities, and on the other with those of the Coal. This I consider to be of importance, since it might otherwise be supposed, that the enigmatical supraposition of the plant-beds at Petit-Cœur upon the Lias might be explained by considering those anthracitic beds to have been erroneously referred to the same formation as the others.

When we compare this flora with that of the Lias, we perceive a total difference. Already in the Permian system new species and distinct genera occur which are wanting in the Coal: still more is this the case in the Trias. Not only are the species all distinct, but all those forms which had played the most important part in the Coal-

* [Quart. Journ. Geol. Soc. vol. v. p. 147, note.—Ed.]

formation have disappeared. We see no more *Sigillariæ*, no *Lomatophylleæ*, *Stigmariæ*, *Annulariæ*, and *Asterophyllites*; the *Lepidodendra* are gone, and in their place the *Equiseta* by their abundance and gigantic size form an important feature in the flora, and together with *Cycadeæ* and *Coniferæ* constitute its principal characteristics.

To this Triassic group follows that of the Lias, whose flora in many respects reminds us of that of the Trias, and especially of the Keuper, but which is wholly distinct from that of the Coal. Reckoning the plants lately discovered by Fr. Braun at Culmbach, near Baireuth, the Liassic species at present known amount to 145. All these, without exception, are wholly different from any of the Coal-period, and but very few are identical with species from the Keuper. Not the species only, but the greater part of the genera, nay whole families of the Coal-period had ceased to exist; such as *Sigillaria*, *Stigmaria*, and *Asterophyllites*. The Ferns and *Equiseta* no more compose the forests; the former, though still abundant, appear under peculiar forms with digitated leaves and reticulated venation (*Sagenopteris*, *Camptopteris*, *Thaumatopteris*, *Laccopteris*, *Clathropteris*). As forest-trees, peculiar coniferous plants, such as *Araucaria*, *Brachyphyllum*, and *Palissya*, with numerous *Cycadeæ*, appear for the first time.

Such was the flora of the Liassic period in the North of Germany: but if the view of Elie de Beaumont be correct, at that same time in our vicinity there existed a flora which not only was totally distinct from it, but which exactly agreed with the incomparably older flora of the Coal; and that not merely in families and in genera, but even in respect to species. We are to suppose that a member of the Coal-flora had continued to exist down to the Liassic period in a broad strip of land from the Isère Department in France all the way to Carinthia; or rather, since the earth had undergone so many revolutions in the interval, we must suppose it recreated; while during the deposition of the Keuper at a much earlier period at the distance of but few miles from this strip of land a totally distinct vegetation flourished in the Canton of Basle, and during the formation of the "Bunter Sandstein" a flora prevailed in Alsace which also was completely distinct from that of the Coal. According to the hypothesis, we first have the Coal-flora, followed by that of the "Bunter Sandstein" and of the Keuper; to this last succeeds that of the Lias, which, in all the anthracitic districts, presents us with Carboniferous plants, while in every other locality it has characters perfectly distinct from the Coal and allied to the Keuper. To this Lias-flora, composed of two such heterogeneous elements, that of the Oolite succeeds, which again is intimately connected with the true Liassic flora, and which, even in the Department of the Isère near the anthracitic districts (as Scipion Gras has shown), possesses the true distinctive characters of an Oolitic flora, and nothing of a Carboniferous one! Nay more—I have discovered in the lower Lias of the Canton of Aargau, near Müllingen, the stem of a *Cycas*, associated with Insects; which proves that in our Lias also *Cycadeæ* played a part, whilst in the anthracites not the slightest trace of such a form has been found. If the views of that geologist were just, a member of the peculiar

Coal-flora has been introduced into the distinct floras of the Trias and of the Lias, and that only in one spot, while all the land in the neighbourhood had a vegetation which exhibits so strikingly the connection in the development of the vegetable creation. This hypothesis so contradicts all our experience of the history of its development, that it cannot longer be supported; and the more, when we consider that the Coal-flora as far as it is known had the same characters over the whole surface of the earth, and at its most distant parts the very species were partly identical. Of the Lias it is not yet known whether its plants had so wide a distribution; but we do know (and we owe this important fact to Sir R. I. Murchison) that in much later times, in the Nummulitic Formation, a great similarity of the molluscous fauna obtained throughout Europe all the way to India, and that the same characters may be traced from Spain and Morocco to the Brahmaputra in India, and from the northern slope of the Alps to Egypt.

It has of late been occasionally asserted that plants do not present discriminating geognostic characters, so that we are further called upon to assume that they were subject to a law of development different to that of animals. But before admitting that different laws subsisted for the two natural kingdoms, better grounds must be adduced than have been hitherto brought forward. Sir R. Murchison instances the *Calamites arenaceus*, as a proof that, in determining the age of a deposit, the presence of certain plants is not so conclusive as that of animals*: but here there is an oversight; for Brongniart, who is quoted, never speaks of that plant as occurring in the old Coal-formation, but only in the Trias. Moreover, it must not be overlooked, that identifications founded only on parts of the stem are not so satisfactory as those deduced from foliage: consequently *Calamites* and *Equiseta*†, which are principally known from small parts of the stem, are less proper for certainty of comparison and for drawing conclusions. But this arises from the state of preservation of those plants, and in nowise from peculiar species not being restricted to determinate periods. Whenever the characteristic organs of plants are well preserved, they are as good indications of the age of the beds as animals;—a truth which is more and more established, the more plants are studied and made known to us. The conclusions, however, which we draw from them will have the more weight when they are derived, not from one or two isolated species about whose identification doubts may be entertained, but from the union of several species and the aspect of the entire flora, as is the case with the flora of those anthracitic schists.

When Sir Henry De la Beche‡ undervalues the certainty of geo-

* *Loc. cit.* p. 178.

† [See observations on *Calamites*, *Equiseta*, and *C. arenaceus*, *supra*, Part I. pp. 189, 190.—Ed.]

‡ Biblioth. Univ. de Genève, Oct. 1849. [This has reference to an Abstract of Sir H. De la Beche's remarks on the Petit-Cœur Anthracite and the dispersion and accumulation of plants, as given in his Presidential Address 1849 (Q. J. G. S. vol. v. pp. xxxviii–xlii). But Sir Henry's observations only apply to fossil plants as indications of the climate at the time when, and on the spot where, they were accumulated.—Transl.]

logical results founded on fossil plants, seeing that they may have grown at very different levels above the sea and may have been carried from a great distance by rivers or sea-currents, he does not reflect that the same is true of animals‡; and also that the mode of preservation and other circumstances will show whether or not the plants have travelled from a distance. When, as in the London Clay, we find only single specimens of fruits, we have good reasons for surmising that they have come from a distance; but when the delicate parts of plants are well preserved, the leaves uninjured and still adhering to the stems, and spread out upon the rock as those in the anthracitic schists are, we cannot believe that they have been transported far, and this is rendered still more improbable when they occur in great quantities and over a wide district.

List of Anthracitic Plants in the Zurich and Basle Museums.

[The species marked thus (*) have not previously been observed in the Anthracitic schists; those marked (†) have not yet been found in Coal-measures; those without a mark are true Coal-plants. Those described by Unger from the Anthracitic schists of the Austrian Alps are marked (Aus.).]

(*)1. SPHENOPTERIS TRIDACTYLITES, Brongn. Hist. Pl. Foss. pl. 50 (?).

Petit-Cœur; Col de Balme.

The specimens are not perfect enough for accurate identification, but by the form of the leaves seem to belong to this species. The pinnæ are in pairs; the pinnules standing apart, and almost at right angles to the long leaf-stalks. The latter are rather smaller than those figured by Brongniart, but of the same appearance: they are also pinnate, the lower leaflets dividing into three, while the upper have their edges entire.

(*)2. NEUROPTERIS LOSHII, Brongn., pl. 73.

Erbignon, in the Valais.

3. NEUROPTERIS GIGANTEA, Sternb.

Petit-Cœur; Erbignon; the most abundant species there.

The venation is well preserved in many specimens. The midrib ceases in the middle of the leaflet; the side-ribs run in slightly curved lines to the rim, and bifurcate.

‡ So also the drift-wood, washed ashore in Iceland, &c., and often quite covered with Bivalves, Serpulæ, and other marine animals, has frequently travelled from a great distance. With seaweed also great quantities of salt-water animals are transported from distant regions. But altogether the contrary obtains with land-animals and land-plants, which in the water fall to the bottom and perish; the drift-wood shows no longer any flowers and leaves, for all these softer parts of the plant have disappeared, and the stronger woody part only remains.

4. NEUROPTERIS TENUIFOLIA, Schl. sp.

Erbignon; Col de Balme; Petit-Cœur.

5. NEUROPTERIS FLEXUOSA, Sternb.; Brongn., pl. 68. fig. 2.

Moutiers.

Together with the long slender leaflets of the *N. flexuosa* are imbedded two larger and broader leaflets, which closely resemble the *N. rotundifolia*, Brong. But, according to Bunbury, *N. flexuosa* presents a variety with broad leaflets, from the anthracite of Martigny. Probably the *N. rotundifolia* which Brongniart found in the Col de Balme and La Roche Macot belongs to the same species. *N. flexuosa* has a very wide range in the Coal-measures; and is found in North America, and especially in Pennsylvania, more abundantly than with us.

(*)6. NEUROPTERIS HETEROPHYLLA, Sternb.

Erbignon, on the same slabs with *N. gigantea.*

(*)(†)7. NEUROPTERIS ESCHERI, Heer.

Fronde pinnis inferioribus (?) pinnatis, pinnulis oblongis; pinnis superioribus pinnatis, pinnulis ovatis obtusis pinnati-partitis 3–5 lobis rotundatis, terminali lateralibus vix majori.

Petit-Cœur, on the same slabs with *Pecopteris pulchra, Annularia brevifolia,* and *Asterophyllites.*

On the stone there are three pinnæ, which I believe belong to one another, although one in the form of its leaflets differs greatly from both the others. Probably the one was attached higher up the frond, and the other two held a lower position. If this be the case, our species very closely approaches *N. heterophylla,* where we find both these forms of leaflets on one pinna. However, it differs from it in the pinnules being rather smaller and slenderer, and in the pinnules at the point not being larger than those at the sides. For the same reasons our species cannot be united to *N. Soretii,* in which, moreover, the pinnules are rather differently formed. The pinnules which I conceive to be the lower ones on the pinna are long; the pinnules towards the point of the pinna become gradually smaller, and the extreme pinnule is very small, and indistinctly lobed at the base: these pinnules stand pretty far apart, so that their edges do not touch; they are longish, and obtusely rounded anteriorly and at the base. The venation is very indistinct, but can be made out in some of the leaflets. The midrib is very stout, but loses itself outwards: from it proceed fine side-veins in a somewhat oblique direction, which bifurcate.

The other pinna, which I believe to have been higher up the frond, has a somewhat curved leaf-stalk with alternating leaflets. They are pinnate, the lower with five, the upper with three lobes which are very obtusely rounded, the outer one being scarcely greater than the rest. The end of the pinna is not preserved.

Near this there occurs a pinna with seven pinnules, which probably belongs to the same plant. Thus the pinna may have had seven pinnules at the base, five in the middle, and three at the extremity.

This beautiful plant has been named by me after M. A. Escher, who brought it from Petit-Cœur.

(†)8. Neuropteris Soretii, Brongn.

Erbignon; Petit-Cœur.

(†)(Aus.) 9. Neuropteris alpina, Sternb.

Erbignon; Petit-Cœur; Col de Balme.

This species, first found at the Stang-Alp in Styria, appears frequently in the anthracitic schists, and has a wide range among them. It is especially remarkable from having the bases of the pinnules connected for their whole breadth with the leaf-stalk [*adnate*].

10. Odontopteris Brardii, Brongn.

Col de Balme; Petit-Cœur.

One of the most abundant plants in the Anthracite: but, as Mr. Bunbury has also observed‡, it is rare to find specimens with such sharp-pointed leaves as in Brongniart's figure (pl. 76).

11. Odontopteris obtusa, Presl, sp.; Brongn. pl. 78. f. 3, 4.

Petit-Cœur.

Between this and the *O. Brardii* there are intermediate forms, which make it probable that the first is a variety of the other. In one specimen the leaflets are not symmetrical, as Bunbury has noticed, being longer, slenderer, and more pointed on one side of the pinna than on the other.

(*)12. Odontopteris minor, Brongn.

Col de Balme.

The Museum at Basle possesses a large and beautiful frond of this plant: it is 102''' long: the main stem is stout and of uniform thickness; so that the leaf must have been still longer. The pinnæ stand wide apart and at very different distances: they are about 35''' long, and furnished with lanceolate leaflets about 3''' long, which do not touch one another. Near this large frond lie some separate pinnæ, and another fragment of a frond near the extremity where the pinnæ are closer together.

(*)13. Cyclopteris reniformis, Brongn.

Erbignon.

A specimen in the Basle Museum agrees well with this true Coal-plant. The leaf is large, reniform, hollowed out at the base; not entirely preserved. The ribs at the base are strong, and bifurcate.

‡ Quart. Journ. Geol. Soc. 1849, vol. v. p. 138.

Var. *b*. Much smaller.

Petit-Cœur.

Several leaves of the same size are associated on the same stone with *Odontopteris obtusa* and *Cyatheites Schlotheimii*. The leaf is of the size of *C. Bokschii*, Göp., and therefore much smaller than that of *C. reniformis*: its length and breadth are each about 10‴. It agrees with it, however, in shape and venation, so that I have for the present considered it as a variety. Possibly better specimens may prove it to be a distinct species; or else that the smaller leaves belonged to the outer and the larger to the lower part of the entire plant. The leaf is broad at the base, and moderately rounded and reniform: its rim, as far as it is preserved, is entire: the veins are fan-shaped, thick at the base, moderately curved and forked, becoming remarkably slenderer after the bifurcation. It differs from *C. Bokschii* in the rounding at the base, and in the veins being less close and being thickened at the base.

14. Cyatheites Schlotheimii, St. sp. (*Pecopteris cyathea*, Brgn.)

Col de Balme; Petit-Cœur.

From the first locality we possess a very beautiful frond. The leaf-stalk is moderately stout; the pinnæ very long and elegant; they have a great number of pinnules which only touch at the edge, and do not overlie each other. This species is not unfrequent in the Anthracite, and is one of the most widely distributed of the Ferns of the Coal-measures in Germany, France, and North America.

(Aus.) 15. Cyatheites arborescens, Brongn. sp.

Col de Balme; Petit-Cœur; La Mure; Montagne de Bacule Carienne (Dauphiné).

This species is even more abundant than the preceding, and has also been found in Styria. We possess several elegant fronds, which exactly agree with Coal-measure plants. Bunbury considers this species and the preceding to be the same, but I think erroneously, since in this species the pinnæ are slenderer, the leaflets smaller, shorter and blunter, and hence the edges of the pinnæ run in straighter parallel lines.

Var. *b*. C. platyrrhachis, Brongn. sp.

Petit-Cœur; Col de Balme.

On the reversed side of the same specimen which contains the beautiful stems of the *C. Schlotheimii*. The pinnæ and leaflets have exactly the form of *C. arborescens*, and accordingly Göppert and Unger unite the two; but Brongniart distinguishes the above, as its leaf-stem is very broad; it is much broader and therefore much thicker from its origin than in *C. Schlotheimii*.

(*)16. Cyatheites Candolleanus, Brongn. sp.

Montagne de Bacule Carienne (Dauphiné), on the same slabs with *C. arborescens*.

Agrees in all respects with the Coal-plant, except that the pinnules are slenderer.

(Aus.) 17. CYATHEITES POLYMORPHUS, Brongn. sp.

Erbignon.

18. ALETHOPTERIS BRONGNIARTI, Göpp. (*Pecopteris pteroides,* Brongn.)

Seems to be the most abundant Fern in La Mure. In some cases the edges of the leaflets seem to be rolled up, as in *Pteris.*

19. PECOPTERIS PLUCKENETII, Schl. sp.

Col de Balme.

The Basle Museum possesses a splendid fragment of the lower part of the frond from this locality. From the stem, which is stout, run long pinnæ standing pretty close together, so that the leaflets of adjoining pinnæ partly cover each other. The pinnæ are divided into a great number of secondary pinnæ (twelve can be counted on each side of an imperfect pinna, wanting its summit); each of these is pinnated with six to eight lobes, which are united at the base and obtusely rounded. This precisely agrees with the upper two pinnæ in tab. 107. fig. 3 of Brongniart. In our collection we have a beautiful stem from the Coal-measures of Zwickau which answers to the lower pinna of the same figure.

(*)(†)20. PECOPTERIS PULCHRA, Heer.

Fronde bipinnatâ, pinnis pinnulisque patentibus remotis; pinnulis distantibus oblongo-lanceolatis, basi apiceque obtusis integerrimis; nervo medio excurrente, nervis secundariis sub angulo acuto egredientibus.

Petit-Cœur; a well-preserved specimen procured by Escher.

The stalk is moderately thick. The pinnæ stand pretty wide apart, so that their edges do not touch. The pinnæ are not very long; their middle pinnules are longer than those at the base or point of the pinnæ. The pinna-stalk is thin, the leaflets alternately arranged on it, but yet so that they are in pairs. These leaflets are so far apart, that their edges do not touch, and even a considerable interval is seen between them. Some stand at a right angle to the stalk, and others at a slightly acute angle. They are longitudinally-lanceolate, a little wider at the base than across the middle, and obtusely rounded at both ends. They are from $4'''$ to $4\frac{1}{4}'''$ long, and from $1'''$ to $1\frac{1}{4}'''$ wide. The venation is generally obliterated; but sometimes the midrib can be traced to the point of the leaflet, and delicate secondary veins branching obliquely from it. These are easily distinguished from the lower pinnæ of *Neuropteris Escheri,* which occur on the same stone, by their more slender shape, and from *Cyatheites Schlotheimii* by the pinnæ being much shorter, and by the leaflets being longer, slenderer, and further apart. They agree best with that subdivision of *Pecopteris* with pinnated fronds and entire leaflets, and should be placed among those next to *P. Jaegeri*, Göp., from the coal of Waldenberg; from which it differs, however, by the leaflets being longer and more distant.

21. Sigillaria, sp.

Merian found a large fragment of a stem at Erbignon. Brongniart mentions eight or nine species from the Tarentaise, and among them *S. Brardii, S. tessellata*, and *S. notata*.

(*)22. Lepidophyllum lanceolatum, Brongn.?

Petit-Cœur.

A large, long, lanceolate, entire-edged leaf, gradually narrowing outwardly and divided by a strong longitudinal rib. I saw several specimens, but none with the base and extremity preserved, so that it could not be identified with certainty.

(*)23. Lepidophyllum caricinum, Heer.

Petit-Cœur; on the same stone with *Neuropteris Escheri*.

A long, rigid, straight leaf, of uniform breadth ($1\frac{1}{2}'''$), with a very strong keel-shaped midrib, besides which no longitudinal ribs can be detected. It resembles the leaf of a *Carex*, but probably may be referred to some species of *Lepidodendron*, which sometimes have these long slender leaves. It further resembles *Lepidodendron* in its rigid appearance.

Very like *Lepidophyllum lineare* (*Poacites carinata*), Brongn. (Mém. du Museum, t. viii. t. 14. f. 2), but the leaf is only half as wide, and there are no other ribs besides the stout midrib.

(Aus.) 24. Calamites Cistii, Brongn.

La Mure; small fragment of stem.

(*)25. Calamites undulatus, Sternb.

La Mure.

A large, decorticated fragment of stem. The length of the joints of the stem amounts to one-third the diameter. The striæ were in wavy lines; they are feebly arched, and here and there marked with transverse lines. No papillæ can be traced. The articulations appear as deep transverse furrows.

It agrees with *C. undulatus* in its wavy striæ and the form of its ribs; the ribs, however, are somewhat slenderer, and the joints shorter. Still, as the closely allied *C. Suckovii*, Brongn., has sometimes shorter and sometimes longer joints, this is no ground for separating it from *C. undulatus*. From *C. Cistii* it is distinguished not only by the shorter joints, but by the much greater breadth of the ribs and their undulating lines, in which, as well as in the length of the joints, it also is distinguishable from *C. approximatus*, Schlot.

(Aus.) 26. Calamites Suckovii, Brongn.

This variable plant, so abundant in the Coal-measures and so widely distributed, occurs also in the Anthracite of the Tarentaise and of Styria.

27. Annularia brevifolia, Brongn.

Beudant's Mineral. und Geolog. p. 557. fig. 212.

Col de Balme; Petit-Cœur.

Seems to be pretty abundant: some specimens entirely agree with some from the coal of St. Etienne, near Lyons, and of St. Imbert, which we possess in our Collection; others have rather shorter leaflets. It has thin stalks, furnished with delicate leaf-whorls. These consist of twelve to sixteen leaflets, which are almost wedge-shaped; they widen outwards by degrees, and are obtusely rounded. From the leaf-whorls proceed delicate branches (apparently one on each side), the leaf-whorls on which gradually diminish in size.

The *Annularia fertilis*, Sternb., abundant in the Coal-measures, and also found in the Anthracite of the Stang-Alp, has not yet been detected in our mountains.

(*)28. Asterophyllites anthracinus, Heer.

Caule gracili, foliis verticillatis arcuatis filiformibus, internodis triplo longioribus; verticillis sub-patentibus.

Petit-Cœur.

On the same stone with *Neuropteris Escheri*. Unquestionably the same as Bunbury's‡ *Asterophyllites* No. 12 of the Tarentaise and No. 10 of the Col de Balme, which that botanist compares to *Asterophyllites foliosus*, L. & H.; in which, however, the leaves are longer than the internodes. It differs from *A. longifolius*, St. sp., which Brongniart and Bunbury describe from the Tarentaise, in its shorter internodes, and in the leaves, which are shorter, standing more apart from the stem. The stem is slender, not above 1''' in breadth at the thicker end. Towards the extremity the internodes become shorter, so that the whorls of leaves are closer together. The leaflets are fan-shaped, of almost uniform breadth, standing off from the stem and describing a curved line. From eight to ten appear to form a whorl. [J. C. M.]

On the Slow Elevation *and* Subsidence *of the* Land *in* Switzerland. By Prof. B. Studer.

[Verhandl. d. Schweitz. Naturf. Gesellsch. 1848, zu Solothurn, p. 37–41; and Leonhard u. Bronns Jahrb. f. Min. 1850, p. 221.]

1. In the neighbourhood of the Alps the Molasse has a thickness of from 1000 to 1500 feet, which decreases in proportion to its distance therefrom. The marine organic remains present the same species

‡ *Loc. cit.* pp. 140 & 142.

throughout, although there are several intercalated beds of freshwater origin; and from this, in connection with other facts, we regard the Molasse to have been deposited in water of a uniform and generally slight depth, in a locality where marine and freshwater conditions occasionally replaced each other.

The Molasse without doubt suffered a slow and continuous downward movement, so as to maintain the moderate depth above indicated, notwithstanding the continual filling up by new depositions. Hence we conclude that a fissure existed between the Molasse and the Secondary rocks of the Alps (which have not participated in the subsidence), without doubt in consequence of the previous elevation of the latter.

2. The Aar near Berne, the Sarine near Freiburg, and other rivers, have serpentine courses, like rivers of low plains with little fall, although their deeply-cut channels, traversing an undulating country, have steep banks 30 or 40 metres high. The stair-like terraces of the river-beds show that these erosive operations alternated with periods of rest. The material thus cut through generally consists of "old alluvia," *i. e.* gravel and sand with indistinct horizontal stratification; but often in the lower portion of the channel, and to the height of 10 metres, the perpendicular banks are composed of Molasse.

A stream, however, that has force and fall enough to excavate so deep a channel, can no longer describe a serpentine; hence, these rivers must at first have flowed over ground having only a slight declivity, but which, after the serpentine course was formed, became more and more steep, thus giving rise to the deep cuttings above-mentioned. These conditions may have simply happened thus:—the upper part of these river-courses has been gradually raised by the elevation of the continent; and this is proved,—1. by the traces of a previous filling up of the Alpine valleys some hundred feet above the present surface of the rivers, and, 2. by the preservation of the horizontality of the strata,—in contrast with the verticality and folding of the Molasse beds previously caused by secondary Alpine strata.

The elevation of these alluvia can only have taken place subsequently to the distribution of the erratic boulders, as the serpentine river-courses cut through gravel and loam, inclosing large Alpine blocks, which, however, are never found on the terraces of the river-beds, except where they have fallen down from the undermining of the banks.

The succession of the movements above indicated is as follows:—

1. Elevation of the Alpine district before the Molasse-period.
2. Subsidence of the district bordering the Alps during the Molasse-period.
3. Elevation of the Molasse and the upcast of its strata.
4. Deposition of the old alluvia in the Alpine and Molasse valleys.
5. Deposition of the Erratics.
6. Continental elevation of the Alpine district.

[T. R. J.]

On the Neocomian Formation *of the neighbourhood of* Brunswick. By Von Strombeck.

[Zeitschrift. d. geolog. Gesellsch. vol. i. pp. 462 *et seq.*, and Leonhard und Bronn's Jahrb. f. Min. 1850, p. 230.]

This formation for the most part consists of a bluish grey and sometimes shaly clay (Hils-clay, of Rœmer*), having a thickness of several hundred feet. Towards the upper part, at some spots of limited extent, small crystals of gypsum are found, also beds of argillaceous ironstone nodules, spathic iron, and impure limestone. Organic remains are rare.

Not far from the base of the formation there is an horizon marked by the presence of heterogeneous rocks, occurring in a great quantity and of varying thickness, up to as much as forty feet. They are not, however, constant on the strike, and in some districts they appear to be entirely wanting. The clay, by admixture with lime, sometimes becomes marl, and from this passes into very hard, bluish grey limestone. At other places, in slightly coherent, yellowish grey, argillaceous limestone, occur angular or rounded fragments of clay-ironstone. When the calcareous cement disappears, a bed of pea-ore [Bohn-erz] is found, which bears somewhat of an oolitic appearance. In all these heterogeneous rocks many species of organic remains occur, some in a good state of preservation, others in fragments. At some places the fossils are found imbedded in pure clay. These fossiliferous rocks near the base of the formation are equivalent to the Hils-conglomerate of Rœmer.

This formation rests upon the Upper Jura (Coral-rag and Portland-stone); and where these rocks are absent, as near the foot of the Hartz, it lies upon the Lias with Belemnites and the Opalinus-clay. Near the Hartz it is covered by the Lower Freestone [Quader], which is found as far distant as the neighbourhood of Hornburg; and, where the "Quader" does not exist, as near the Elme and the Asse, &c., it underlies the Variegated Marl [Flammen-mergel].

Gault, such at least as it appears in England, France, and Savoy, is here wanting.

Rœmer has paralleled this formation with the Neocomian of Switzerland and South of France, and with the Lower Greensand of Fitton; and that this opinion is well founded, is proved by the fauna.

In the lower fossiliferous rocks the *Radiata* and *Mollusca* of most frequent occurrence are,—*Toxaster complanatus*, Ag. (*Spatangus retusus*, Lam.), *Pyrina pygæa*, Desor (*Nucleolites truncatulus*, Rœm.), *Terebratula oblonga*, Sow., *T. multiformis*, Rœm., *T. biplicata*, var., *sella*, Sow., *Ostrea macroptera*, Sow., *Exogyra spiralis*, Goldf., *E. sinuata*, Sow. (*E. Couloni*, Defr., and *E. aquila* and *falciformis*, Goldf.), *Pecten crassitesta*, Rœm., *P. atavus*, Rœm. (*Janira atava*, d'Orb.), *Myopsis* (*Panopæa*) *arcuata*, Ag., *Belemnites subquadratus*, Rœm., *Ammonites bidichotomus*, d'Orb., and *Am. Astierianus*, d'Orb.

Palæontologically considered, the Hils-conglomerate of Brunswick

* [See notice of the Hils-clay and -conglomerate, Proc. Geol. Soc. vol. iii. p. 324.—Transl.]

most nearly resembles the *Néocomien inférieur* of Switzerland, as it appears at Mont Salève near Genf. The similarity is the more striking, as *Terebratula multiformis*, Rœm., with the Swiss *T. depressa*, Sow., according to Von Buch, and *T. sella*, Sow., with the Swiss *T. biplicata acuta*, V. Buch, form but one species. Something similar occurs with the small corals of the genera *Scythia*, *Ceriopora*, *Manon*, &c., which at some places are of very frequent occurrence and are elsewhere entirely wanting.

In the clay itself, in which the fossiliferous masses of rock are imbedded, the organic remains are limited to a few species, which occur also in the Hils-conglomerate. The most common fossils are *Pecten crassitesta*, Rœm., and *Exogyra sinuata*, Sow., and also a Belemnite (somewhat resembling *B. subfusiformis*, Rasp., from the Lower Neocomian), which does not occur in the lower fossiliferous rock-masses.

As the faunæ of the upper and lower beds differ only in respect to these *Belemnites*, there does not appear to be sufficient reason for separating the lower fossiliferous portion from the upper beds that are less rich in organic remains. The whole may be considered as a Division of the Cretaceous series, having a uniform fauna, and consisting chiefly of a thick argillaceous deposit, towards the base of which heterogeneous rocks with accumulations of organic remains are of local occurrence.

This formation does not comprise the Upper Neocomian beds of Switzerland, &c., or the *Terrain Aptien* of d'Orbigny.

[T. R. J.]

NEW FOSSILS *from the* VERRUCANO.

A Supplemental Note to the "Considerations of the Stratigraphical Geology of Tuscany," by Professors SAVI and MENEGHINI, of Pisa, appended to a Translation of SIR R. MURCHISON'S Work on the Geological Structure of the Alps, Apennines, and Carpathians* (Now in the Press). 8vo Pamphlet, 1851.

(NUOVI FOSSILI DEL VERRUCANO.

Nota aggiunta alle *Considerazioni sulla Geologia stratigrafica della Toscana, dei* Prof. CAV. PAOLO SAVI e GIUSEPPE MENEGHINI, che fanno seguito alla traduzione dell' Opera di Sir R. MURCHISON *sulla Struttura Geologica delle Alpi, degli Apennini e dei Carpazi*, che si sta pubblicando. 1851.)

THE works in connection with the cinnabar-mine discovered at Jano, and which already have had the very important geological result of leading to the discovery of well-preserved and recognizable impressions of Carboniferous plants in the Verrucano†, have lately been

* [See Quart. Journ. Geol. Soc. vol. v. pp. 157 *et seq.*]
† [See *Ibid.* vol. vi. p. 382, *note.*]

productive of other fossils of still greater importance, namely, of animal remains, belonging to the same period.

The excavation of two galleries, running in a S.W.–N.E. direction at two different levels, has rendered it possible for us to recognize the true disposition of the strata in that part of the mountain, and the relative position of the fossils above referred to and presently to be noticed.

A rough examination of the surface of the ground, encumbered as it is with rocky debris, enables us to perceive that in general the strata strike S.E.–N.W., and dip to the N.E. The mining-works, however, above-mentioned indicate that the strata have a dome-like curvature, the curve presenting its convexity to the N.E., and comprehending in its concavity the greater mass of the anthracitiferous and cinnabar-bearing deposit. From this dome-like arrangement it follows that in the central part of this deposit the superior strata are turned over somewhat to the S.W.

It was in the first portion of the upper gallery, which is driven near the vertex of the dome, that the bed rich in vegetable impressions was met with; but, suddenly passing upwards, it was left behind. The same bed was again encountered in this working by means of a descending gallery, which, at 39 bracchia [about $74\frac{1}{2}$ Eng. feet] distance from the opening, is directed towards the plane of the lower gallery, to the N.W., and thus traverses, in that direction, the curved strata, and consequently is continued from the lower towards the upper beds, in which the latter gallery is now being driven at a lower level.

In excavating the first portion of this second gallery the fossils, that we shall presently enumerate, were met with. It has been previously mentioned that the upper strata consist of great beds of quartzose anagenite [coarse greywacke], which repose on siliceo-talcose schists, of a greyish black colour, more or less compact, alternating with deposits that are somewhat fine and interrupted with anthracite. The uppermost of these schists have a greater compactness and a texture so coarse as to resemble a psammite; the lower beds are of a finer grain, and might be taken for simple argillaceous schists. The latter contain the vegetable impressions; whilst the animal remains are found in the former. Judging from the appearance of the rocks on the surface of the mountain, other beds of anagenite might be expected to underlie the schists with vegetable remains, but as yet the subterranean works have not come upon them.

The most abundant of the animal remains of this locality are those of the Cyathocrinite, undermentioned; the others, excepting those of the few *Brachiopoda*, *Bryozoaria*, and *Polypifera*, all belong to the Lamellibranchiate Molluscs, and consequently to a Class, in which the difficulty of recognizing and determining the species is greater than in any other, especially with such poor remains as are here afforded to us—frequently incomplete impressions, and imbedded in rock excessively altered by metamorphic action. From the very numerous shells, therefore, of the casts of which, in some parts of the fossiliferous stratum, the rock, one might say, is almost entirely composed, we have as yet succeeded in determining with sufficient accuracy only the few following species:—

1. Pholadomya regularis (*D'Orb.*). *Allorisma regularis,* King, Vern. Geol. Russ. vol. ii. p. 298. pl. 19. fig. 6, pl. 21. fig. 11.
2. Pholadomya plicata (*D'Orb.*). *Sanguinolaria plicata,* Portlock.
3. Pholadomya, sp.
4. Cardinia tellinaria (*Koninck*). *Unio tellinarius,* Goldf. Petref. pl. 131. fig. 17.
5. Cardiomorpha pristina (*D'Orb.*). *Amphidesma pristina,* Vern. Geol. Russ. vol. ii. pl. 20. fig. 5.
6. Leptæna arachnoidea (*D'Orb.*), *Phill.* sp. *Orthis arachnoidea,* Vern. Geol. Russ. vol. ii. p. 196. pl. 10. fig. 18, pl. 11. fig. 1.
7. Productus, sp.
8. Spirifer glaber (*Sow.*), *Martin,* sp.
9. Ptilodictya, sp.
10. Cyathocrinus quinquangularis, *Miller.* Eichw. Sil. Syst. p. 172; Phillips, Geol. Yorks. p. 206. pl. 3. fig. 30–32.
11. Ceriopora irregularis (*D'Orb.*). *Alveolites irregularis,* Koninck, Carb. Belg. pl. B. f. 2; Michel. Zooph. pl. 60. fig. 4.

The discovery of these most important organic remains shows that we were not altogether deceived in assigning the age of the Carboniferous period to the rock, termed by us the Verrucano, since, there being some degree of uncertainty as long as fossil plants only were known to be present in it, the occurrence at a higher level in the same rock of animal remains, belonging to that period, removes any doubt that could possibly remain on this point. This case is widely different from that of the Tarentaise, because we have not here the mysterious commingling of Jurassic fossils with Carboniferous plants, but on the contrary we find, and that too in their normal position, remains of the most characteristic species of animals of this latter period.

We have recently collected, and MM. Pitiot and G. Begni have courteously favoured us with, several specimens of impressions of plants from the same anthracite-bed that supplied the species above-enumerated. These are—

1. Calamites, sp.
2. Nephropteris orbicularis, *Brong.*, Tabl. p. 16.
3. Odontopteris Schlotheimii, *Brong.*
4. Pecopteris (Aplophlebis) acuta, *Brong.*

The other plants included in our list of Tuscan fossils [Consid. Geol. Strat. Toscana] are—

5. Neuropteris rotundifolia.
6. N. allied to *N. Voltzii,* Brong.
7. N. allied to *N. elegans,* Brong.
8. N. sp.
9. Adiantites, sp. nov.

10. Pecopteris (Aplophlebis) arborescens, *Brong.*
11. P. (A.) allied to *P. unita*, Brong.
12. P. (A.) resembling *P. æqualis* and *aspersa.*
13. P. (A.) allied to *P. arborescens*, Brong.
14. P. (Dicrophlebis) cyathea, *Brong.*
15. P. (D.) Bucklandi, *Brong.*
16. P. (D.) allied to *P. nervosa*, Brong.
17. Calamites, sp.
18. Annularia longifolia, *Sternb.*

[T. R. J.]

Sketch of a Geognostico-geogenetical Description of the AIX-LA-CHAPELLE DISTRICT. By Dr. M. H. DEBEY. pp. 67. 4to. Aix-la-Chapelle. 1849. With a Lithographic Plate of Sections.

[Entwurf zu einer geognostisch-geogenetischen Darstellung der Gegend von Aachen, u. s. w.]

THIS memoir is a short sketch of a more extended monograph on the rocks and fossils in the neighbourhood of Aix-la-Chapelle, and more especially on the Cretaceous series of that district. This Formation is here remarkable for its lower sand- and clay-beds, which contain a rich and beautiful Flora.

In dividing the Chalk-formation of Aix-la-Chapelle into groups, and comparing them with those of the classical localities of this Formation in Bohemia, Saxony, and England, the author finds himself at variance with many geologists; especially as regards the question whether all the Cretaceous deposits of Aix-la-Chapelle are superior to the Gault, or whether beds chronologically equivalent to the Gault, and even to still lower deposits, viz. the Shanklin Sand, are present there. Dr. Debey considers that the latter is the case.

The geographical distribution of beings is necessarily regarded by the author as of great importance in proving that deposits perfectly synchronous may in different countries present very different faunas and floras; and he points out that in this manner the Cretaceous basins and gulfs of England, France, Aix-la-Chapelle, Saxony, Bohemia, Silesia, &c., may present local peculiarities and little specific identity of organic forms, and nevertheless may contain beds which, by their stratification, geognostic characters, and generic resemblance of their fossils, are unquestionably of identically the same age.

Commencing with an account of the older rocks of the district, Dr. Debey proceeds to give detailed descriptions of the Cretaceous deposits and of their organic remains. The Aix-la-Chapelle Chalk-formation, having a thickness of 5–600′, is described as lying immediately on the Greywacke and Carboniferous rocks (as also in Westphalia, Bohemia, and Sweden), and constituting a series of littoral deposits of that great Cretaceous sea that extended westwardly between France and Great Britain on both sides of the existing Channel, and eastwardly over North and Central Germany, Sweden, Poland, and Russia, far into Asia. The following serial arrangement (in ascending order) of the component groups of the Aix-la-Chapelle series is given at p. 5.

Divisions.			Feet (German).
I. Lower	1. Aix-la-Chapelle Sand with intercalated clay-beds (Aix-la-Chapelle Chalk-loam [Aachener Kreideletten])		250 to 300
II. Middle	2. Lower Greensand of Aix-la-Chapelle		15 — 50
	3. Gyrolite-greensand		10 — 50
III. Upper	4. Upper Greensand and chloritic Chalk		5 — 10
	5. Chalk-marl	*a.* Without Firestone	5 — 50
		b. With Firestone	5 — 50
IV. Uppermost	6.	Lusberg Breccia	$1\frac{1}{2}$ — 2
		Vetschau and Kunraed Chalk-marl	15 — 50
	7. Vetschau and Kunraed Coral-chalk		6 — 10
	8. Hornstone		
	9. Valkenberg and Maestricht Chalk-tuff		5 — 250

The last (No. 9) does not occur in the district under consideration.

The fauna and flora of the "Lower Division" of the above series are of considerable interest. It is subdivided by the author into three groups.

The *lowest* exposed beds of the "Aix-la-Chapelle Sand" contain but a small proportion of vegetable remains.

The *middle* group is remarkable for the great abundance and variety of its flora. It contains remains of delicate stems, leaves, flowers, and fruits, and the resin of Conifers. The epidermis of whole leaves sometimes occurs in a slightly carbonized state, and recognizable by its microscopic structure. Xylophagous Molluscs are found in the petrified and carbonized wood, and Infusorial remains occur in the clay.

In the *upper* group, the sandstones contain a great quantity of vegetable detritus, amongst which occur some branches, with or without fruits (*Cycadopsis*). Very rarely a few marine organic remains accompany the above (*Cardium Becksi*, Müll.). In the Sand-beds a few marine remains have been found, viz. *Turritella* and *Trigonia alæformis*. Lastly, a small local patch of peculiar sandstone affords *Ostrea vesicularis* (very rare), a quantity of other *Ostreæ*, a Gasteropod resembling *Cerithium*, and which, although it reminds one of *Turritella costulata*, Goldf., from the Oolite, is nevertheless peculiar to this sandstone; also a fragment of a large *Tornatella*, a new *Patella*, and another.

A comparative view of the palæontology of the different members of the Chalk-formations of Aix-la-Chapelle, Bohemia, and England, is given in a tabular form, and is succeeded by a consideration of the Cretaceous Flora; especially of Saxony, Silesia, and Aix-la-Chapelle. By its richness in *Algæ* and Ferns, &c., says the author, and by its poverty in *Cycadeæ* does the Aix-la-Chapelle Cretaceous flora differ from most of the others. The *Coniferæ* and partially the Dicotyledonous leaves, however, indicate an evident relationship. The *Cunninghamites* (Saxony, Bohemia), *Geinitzia* (Bohemia), *Araucarites* (Bohemia), and the *Lycopodites* (Saxony), which probably belong to the Conifers, are forms decidedly allied to the *Cyca-*

*dopsis**, and indeed it is probable that ultimately some of the above will prove to be identical with the last-named genus.

Of the Dicotyledonous leaves it is worthy of remark that the *Phyllites Geinitzianus* and *Ph. emarginatus*, from the "Quader" of Silesia, lately described by Prof. Goeppert in the Acta Leop. vol. xxii. pt. 1. p. 361. figs. 5, 6, 7, 10 and 11, exhibit an agreement with Dr. Debey's genus *Bowerbankia*†; whilst, on the other hand, of the *Crednerieæ* (which especially appear to belong to the "Upper Quader" of Blakenburg, occur only as a few species in the Silesian "Quader" and in the Niederschöna beds, and are altogether wanting in the Bohemia "Quader") there is not a trace in the Aix-la-Chapelle Sand.

A stratigraphical arrangement of the best-determined vegetable remains of the whole Chalk-formation exhibits the greater prevalence of plants in the *lower* Cretaceous rocks of Germany. The proportion is approximately as follows‡:—

	Upper Chalk. White Chalk. Upper Quader?	Middle Chalk. Greensand. Gault.	Lower Chalk. Lower Quader. Aix-la-Chapelle Sand.
Algæ	12	0	15
Filices	6	0	28
Hydropteridæ	0	0	2
Cycadeæ	0	3	5
Naiadeæ	1	1	5
Palmæ	1	0	1
Coniferæ	4	4	20
Julifloræ	0	3	5
(Crednerieæ)	5	0	3
Leaves (Dicotyledonous), undetermined	4	1	26
Fruits, undetermined	0	0	8
Woods, undetermined	—	—	—

The remainder of the memoir is occupied by much interesting matter relating to the Chalk-formation,—especially, a review of the faunas of the Cretaceous deposits of different countries, and general considerations on the Cretaceous Period,—and by a description of the Tertiary and Post-tertiary deposits of the neighbourhood of Aix-la-Chapelle. [T. R. J.]

* For description of this genus and of six species from the Iron-sand of Aix-la-Chapelle, see Dr. Debey's paper, Ueber eine neue Gattung urweltlicher Coniferen aus dem Eisensand der Aachener Kreide. Verhandl. nat. Vereins preuss. Rheinl. Bonn, 1847, p. 126 *et seq.*

† Some of leaves are from 4 to 6 inches in length, and occur in a beautiful state of preservation. [Dr. D. *in lit.*]

‡ This Table is corrected from that published by Dr. Debey, together with a list of Cretaceous plants with references, synonyms, &c., in his Paper, Uebersicht der urweltlichen Pflanzen des Kreidegebirges überhaupt und der Aachener Kreideschichten insbesondere. Verh. Ver. pr. Rheinl. 1847, p. 113 *et seq.*

On the Elevation *of the* Coast *of* Sweden. By M. Nilsson.

[Leonhard u. Bronn's Neues Jahrb. f. Min. u. s. w. 1850, p. 477; and Biblioth. univ. Genève, Sc. phys. 1851, p. 149.]

In a work on the Existence of Man in Scandinavia previously to the historic age (Forhandl. Skandin. Naturf. 4. möde i Christiania, 1844, Chr. 1847, p. 93–109), the author furnishes some interesting data relative to the elevation of the land in that region. A rock, named Gudmandz Schäre, in the harbour of Fjellbacka (Lat. 58° 35′), has offered opportunities of careful examination; and hence it has been established that in 1532 the rock was 2 feet below the surface of the sea,—in 1662 it was 7 or 8 inches above the surface,—in 1742, 2 feet, —and in 1844, 4 feet above water. Thus it has risen 6 feet in 300 years—or at the regular rate of one foot in fifty years. [T. R. J.]

On Arkansite. By A. Breithaupt.

[Poggendorff's Annal. d. Phys. t. lxxvii. pp. 302 *et seq.*; and Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1850, p. 846.]

The new mineral Arkansite*, discovered by Dr. Shepard near the Hot Springs†, Arkansas, U.S., is described as being peculiarly interesting in a crystallographic point of view. The following are its chief characteristics:—

Externally the lustre is always semi-metallic, somewhat approaching a metallic diamond-lustre. Externally the surface of the crystals have a more or less metallic appearance. Colour iron-black. Streak dark ash-grey. Quite opake. The primary form, as seen in the crystals, appears to be a brachyaxial, rhomboidal pyramido-hedron. The author observed several combinations, but a detailed description of them cannot be well understood without the figures. The cleavage is not distinct. Fracture uneven. Compact masses of this mineral form a rather loosely coherent, granular compound. Hardness$=7\frac{1}{4}$ to 8. Specific gravity$=3{\cdot}952$.

Arkansite is found mixed with greyish-white quartz; and both have unmistakeably the appearance of occurring in veins.

[T. R. J.]

On the Tchornoi Zem *of* Russia. By Prof. Ehrenberg.

[Monatsbericht Akad. Wissensch. Berlin, July 1850, pp. 268 *et seq.*; and Biblioth. Univ. Genève, April 1851, Sc. Phys. p. 329.]

The Tchornoi Zem or Black Earth of Central Russia, covering more than 60,000 geographical square miles, and of extreme fertility,—supporting more than 20,000,000 of souls, and giving rise to an annual exportation of about 20,000,000 hectolitres [=55,000,000

* See Quart. Journ. Geol. Soc. vol. vii. part 2. p. 90.

† [This mineral occurs also in geodic masses in the Silurian slates near Tremadoc, North Wales.—Transl.]

bushels] of cereals,—was described by Sir R. I. Murchison in 1842*, and was considered by him to be a submarine deposit, accumulated in quiet water, and possibly of nearly the same age as the Loess of the Rhine. M. Ehrenberg, on examining the Black Earth under the microscope, found in it 6 forms of Polygastrica and 22 of Phytolitharia; and concludes that it is not an aqueous deposit, but rather a soil formed of the debris of ancient forests;—an origin hypothetically given† to this peculiar formation by earlier observers.

[T. R. J.]

On the OROGRAPHY *and* GEOGNOSY *of the* NORTH-WEST COAST *of* N. AMERICA *and the* OUTLYING ISLANDS. By Dr. C. GREWINGK. pp. 351, large 8vo. St. Petersburg, 1850. With 5 Maps, and 4 Lithographic Plates of Fossils.

(*Beitrag zur* KENNTNISS *der* OROGRAPHISCHEN *und* GEOGNOSTISCHEN BESCHAFFENHEIT *der* NORD-WEST-KÜSTE AMERICAS, *mit den* ANLIEGENDEN INSELN. Von Dr. C. GREWINGK.)

IN the Transactions of the Mineralogical Society of St. Petersburg, 1847, pp. 142–163, appeared some geological observations on Old and New California, by Dr. Grewingk, from communications and collections made by M. Ilia Wosnessensky. The work, the title of which is above given, is the result of still richer communications from the same, and treats more especially of the Russian-American colonies. It is divisible into two parts. In the former we find descriptions, geographical and geological,—1. of the Western half of North America, between the parallel of San Francisco and the mouth of the Stachin (56° 30′), with the adjacent islands; 2. of the continent in the parallel of Sitcha;—the peninsulas Tschugatsk and Aliaska, and Kenai Sound (Cook's Inlet); 3. the western coast of North America lying between 59° and 69° lat., with the neighbouring islands; 4. the principal islands adjacent to the Aliaska Promontory; 5. the Aleutian Islands; and 6 & 7. the outlying islands.

The second part of the work contains,—1. an account of the Volcanic phænomena on the north-west coast of America and in the adjacent islands, geographically arranged; 2. a chronological survey of the same phænomena, and an account of the general geological characters of this region; 3. an Appendix (No. 1) relating to the fossil remains of animals and plants hitherto found in the Aleutian Islands and the North-west American coast; and 4. Appendix No. 2, in which is given a classified arrangement of the materials for a history of the voyages, travels, and discoveries in the western half of North America and in the neighbouring seas.

The volcanic and general geological characters of the Aleutian Islands and the N.W. American coast are to a considerable extent laid down on the map of the district (Pl. II.). The author, how-

* Proc. Geol. Soc. vol. iii. pp. 712 *et seq.*; and Geol. Russia, vol. i. p. 557.

† *Loc. cit.* p. 714.

ever, wishes this to be regarded merely as a sketch-map,—the first attempt at mapping the geognosy of this region, without any pretensions to the accurate determination of the boundaries of the deposits there observed.

Appended to the Map is a profile-sketch of the mountains of the region under notice. Of these Mt. S. Elias (143° W. long., 60° lat.) on the continent is the highest, being 16758′ high; in the Aleutian Isles the volcano Schischaldin (164° W. long., 54° 40′ lat.) is the highest elevation (8953′); and in Kamschatka the loftiest is Kljutschewskaja Sopka (56° 4′ lat.), being 13876′ high.

Diluvial formations were recognized, by means of their *Mastodon* remains, at Unalaschka, the Pribülow Islands, Norton Bay, Kotzebue Sound, and the coast further north of this; and indications of these deposits were observed at Cook's Inlet and on the Aliaska coast. The distribution, however, both of alluvium and diluvium can only be correctly defined when the country is better known.

The Tertiary formation is chiefly represented by the Brown-coal beds. These occur on the Pribülow and Fox Islands, both coasts of Aliaska, Kadjak, east coast of Cook's Inlet, Altna Bay, Great and Little Bodega, the mouth of the Sacramento, and from St. Jose to Monterey. The fossils from the Aleutian and Pribülow Islands, Aliaska, Unga, Kadjak, and the Great Bodega belong to one period. Although they are very closely allied to the existing molluscs of Beering's Straits, and in some cases exhibit, perhaps, perfect identity (see Appendix No. 1), yet material differences present themselves in the recent and fossil faunæ, and the author is induced to ascribe these fossils to the Newest Tertiary period. Herein, says he, we have been especially guided by the surprising similarity of the fossils from the Tertiary basin of Beauport, near Quebec, on the St. Lawrence*, which appear to be very nearly allied to the Newest Pliocene beds of Scotland. Moreover, the Kamschatka Tertiary formations, noticed by Erman, will, perhaps, after more accurate research, exhibit the same analogies; and herein we have another proof that a general uniformity of the northern fauna, corresponding to the existing distribution of animals in the north, had existed at early periods. The author points, also, to the possibility of the existence of analogical conditions with regard to the Pliocene Tertiary beds on the northern slopes of the Caucasus.

Jurassic rocks were met with only in Katmai Bay, on the S.E. coast of Aliaska.

Indications of the Coal-formation occur on the Columbia river, at Vancouver, and Unga; and it is probably present on the northern parts of the east coast of Beering's Straits, as also in the Icy Sea, from Cape Thompson to Capes Lisburn and Beaufort.

The existence of Silurian rocks in this region, and that to a great extent, is considered probable; but no decided evidences were met with, excepting a rolled fragment of *Catenipora escharoides,* from Sitcha, and indications of these rocks on the north coast of Beering's Straits. [T. R. J.]

* Lyell, Trans. Geol. Soc. vol. vi. pt. 1. p. 135–139.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On Crinoidal Remains *in* Fluor-Spar. By A. L. Slack.

[Jahresbericht naturw. Verein. Halle, 1850, pp. 77–79.]

Lately, in breaking a specimen of Derbyshire fluor-spar in my collection, which was remarkable for its irregularity of shape, I was astonished at finding some column-joints of *Rhodocrinus verus*, Goldf. As is well known, there is a very fine specimen of a Crinoidal stem enclosed in fluor-spar, also from Derbyshire, in Werner's collection at Freiberg, and regarded of great importance by Werner and all mineralogists. Immediately on perceiving the crinoidal joints in the freshly broken fragments, I felt the impossibility of assenting to Werner's explanation of the phænomenon; and I proceed to describe my specimen in detail, and the more so as a third of the sort is not known to exist*.

The mass was a foot† long, and half a foot wide, by three inches high. For half its height it consists of fluor-spar crystals in cubes of from three-quarters to one inch in size; the colour is dark, almost indigo-blue, and translucent; the surface bluish-grey and opake. The lower half is composed of small-grained, laminose fluor-spar of the same colour, in which are enclosed light-yellowish and brownish earthy substances, forming nearly an eighth part of the whole. The lower face is also covered with small blue crystals of fluor-spar, and a few scalenohedral crystals of calc-spar. There is a sharp horizontal plane of separation passing through the length of the mass between the crystalline half and the lower small-grained half.

From its shape, the specimen broke into several pieces some inches in size. On the limits of the granular and the crystalline fluor-spar, and projecting into the latter, I immediately perceived two stem-fragments, which I recognised as *Rhodocrinus verus*. The one consists of eight connected joints, five of which lie in the one, and three in the other fragment. These circular joints have a diameter of nine millimetres, and a variable thickness of one to two millimetres. The slightly convex surfaces of the sides appear in the thicker joints to be covered with isolated warts, at least such a wart is clearly discernible on the otherwise crystalline laminated surface. From the circumstance of the stem-fragments being broken with the fracture of

* [Such specimens have been met with not unfrequently at Castleton and Matlock, Derbyshire.—Transl.]

† German measure.

the mass, the articulating surfaces of the joints are rendered freely visible, and these are seen to be covered by a fine coating of ferruginous ochre. The rays do not reach to the nutritive canal, and measure from the rim only two millimetres in length; they are from sixty-five to seventy in number; some of them, however, are split into two. The nutritive canal is obtusely pentagonal, and is also filled with ferruginous ochre. Round about it, as far as the commencement of the rays, the articulating surface is smooth. Consequently these joints perfectly agree with *Rhodocrinus verus,* Goldfuss, tab. 60. fig. 3.

Both in the nutritive canal of the broken column, and between the articulating surfaces of some of the joints, fluor-spar is clearly recognised as having penetrated into those cavities. The joints themselves consist of calc-spar of a yellowish-brown colour, with a clearly rhombohedral structure.

The second stem-fragment shows three very evident joints, which are circular like the former, but are only five millimetres in diameter, and are equal in thickness. The denticulated line of suture of some of the joints is more conspicuous on the surface than in the foregoing, from which it does not differ in other respects.

The third stem-fragment lies altogether in the crystalline portion of the mass, and wants only a part of its outer surface. It has ten grey-coloured joints, of equal size, connected together by denticulate sutures; their diameter is considerably less than that of the foregoing.

A fourth fragment consists of eight partly disunited joints, but otherwise quite similar to those of the third fragment. They are all enclosed in the granular portion of the specimen.

A larger fragment lying on the boundary of the granular and crystalline portions shows three joints, similar to those first described. And in the granular portion, by close observation, we can detect also small isolated joints more or less decomposed.

From the above it appears that the specimen described is fluor-spar metamorphosed from Mountain Limestone, in which the Crinoidal fragments, by reason of their crystalline structure, successfully resisted the influence of the fluoric acid; and preserved their original form, whilst the compact calcareous mass was so completely dissolved by the fluoric acid rising from below, that it became converted into crystalline fluor-spar. The earthy material, which is regularly distributed throughout the granular fluor-spar, appears to consist of the argilla and magnesia [? barytes and iron] originally present in the solid limestone. The phænomenon appears, therefore, to agree with that of calamine long since known. [T. R. J.]

On Recent Notices *of the* Nummulite Formation. By C. Giebel.

[Jahresbericht der naturw. Vereines in Halle, 1850, pp. 47–49.]

M. Giebel here gives a survey of the researches relating to the age and geological position of the Nummulite Beds, made during the two years previous to May, 1850.

According to Ewald's statements, made at the Meeting of Italian Geologists at Venice, the Nummulitic Sandstone covers the Macigno, and both are only different aspects of the same formation ; the Nummulite-limestone generally, however, being divided into three zones. Of these, the oldest, in Provence, belongs to the Chalk-formation, and contains globular Nummulites. The second, regarded as the Nummulite-formation proper, is to be paralleled with the Eocene beds, and contains lenticular Nummulites. Lastly, the third zone overlies the Macigno and is of Miocene age. These general observations of M. Ewald agree with those of all other geologists, at least as regards the localities where they were made.

Near Gmünden, on the Traun, Zeuschner found fossils in the sandy Nummulite-rocks similar to those of the Kressenberg, which is regarded by Ewald as of the Nummulite-formation proper ; and Rosthorn discovered in Istria a grey sandstone, similar to the Gosau formation*, both resting upon and covered by nummulitic strata.

Tallavignes also distinguishes in the Corbieres both an Eocene Nummulite-rock, and one belonging to the Chalk and resting on Hippurite-beds. The former he terms the *Système Ibérien,* and the latter the *Système Alaricien* ; and transfers the date of the elevation of the Pyrenees to the period between the two. This division into an ante-pyrenaic and a post-pyrenaic formation is accepted by Elie de Beaumont, without his admitting the parallelism of contemporaneous beds.

In the Asturias the Nummulite-rock lies on a limestone with *Spatangi,* belonging to the chalk-formation, which contains mistaken *Orbitulites,* according to Verneuil, who met with nummulitic beds only where other eocene strata are wanting above the Chalk, and who rejects, as unfounded, the statements of Pilla, Catullo, and Pasini, respecting the co-occurrence of Hippurites and Nummulites.

Near Teschen [Silesia], Hohenegger collected Nummulites, distinguished by an open spire, in beds characterized by Neocomian Ammonites, Hamites, and Scaphites ; according to which, as Ewald observes, the Nummulites of the Carpathians are apparently still older. The peculiar Nummulites in question do not, however, permit of an identification of the beds to which they belong with other [true] nummulitic rocks, but they will share the fate of Morton's Alabama Nummulites, which D'Orbigny has placed in the genus *Orbitoides,* and the geological relations of which have been reported upon by Lyell.

Researches on the structure of the strata at Karst, near Trieste, gave Kaiser† an insight into the fact that the nummulitic beds had been deposited at an earlier period than the local sandstone, and that the latter had been developed gradually at the expense of the former.

* [Compare Von Hauer's observations on the absence of true *Nummulites,* and the presence of *Orbitulites* (*Orbitoides*) in beds of the Gosau formation, Quart. Journ. Geol. Soc. vol. vii. Part 2. (Miscell.), p. 85 *et seq.*—Transl.]

† [See F. Kaiser "On the Geology of the Vicinity of Trieste," *loc. cit.* p. 35 *et seq.*—Transl.]

Ehrlich, on account of the presence of very characteristic fossils, ascribes an eocene age to the nummulitiferous sandstone near Mattsee, not far from Salzburg.

The nummulite-beds of Switzerland have been examined by Brunner and Rutimeyer; those in the Basin of the Gironde by Raulin; and very valuable general remarks on this Formation have been supplied by Boué and Murchison. [T. R. J.]

On German Tertiary Formations. By F. Sandberger.

[Leonhard u. Bronn's Jahrbuch f. Min. u.s.w. 1851, p. 177.]

Tertiary formations of the age of the Mayence Basin are widely distributed in Germany. That the Brown-coal formations of Westerwald and the Lower Rhine, as also that of the Vogelsberg, belong to this period is easily proved by their fossil shells and plants. With regard to their Vertebrata, von Meyer long since supplied the necessary proof. Moreover the Brown-coal formations of Miesbach in Upper Bavaria contain *Cyrena subarata*, Bronn, *Cerithium margaritaceum*, and other characteristic forms of the Mayence Basin. The Vertebrata of the Molasse of Switzerland agree also with those of the last deposit, and in respect to North Bohemia, the elaborate work of von Meyer and Reuss* affords also a similar result. The Mayence Basin is moreover the type of a whole series of such deposits, as is the London Basin with respect to the old-tertiary clays of the Baltic plain. [T. R. J.]

On an Extensive Rock-formation *of* Siliceous Polycystina *from the* Nicobar Islands. By Prof. Ehrenberg.

[Berlin. Monatsbericht. 1850, p. 476–478. Leonhard u. Bronn's Jahrb. f. Min. u.s.w. 1850, p. 237.]

Hitherto Barbadoes only has afforded rocks with Polycystina. The Nicobar Islands lie in nearly an equal latitude with it, but in the East, instead of the West Indies. They consist of syenitic and serpentinous porphyry or gabbro-rock with pyrites, but without any recent volcanic ejectments, on which, to the height of 2000′, lie clays, marls, and calcareous sandstones rich in *Polycystina*. The author has already obtained from hence 100 species, which are partly identical with the 300 species from Barbadoes. The islands Car Nicobar and Comarta are especially remarkable in this respect, and on the latter exists a hill 300′ high, throughout which the Polycystina-clay occurs. A light meerschaum-like clay and shale (tripoli, polishing shale) found there and at other places is composed nearly altogether of these bodies mixed with many Spongolithes. These clays are generally traversed by lignitiferous deposits and by syenitic gravels.

[T. R. J.]

* Palæontographica, ii. 1.

On the Internal Structure *of* Mountains. By B. Cotta.

[Leonhard u. Bronn's Jahrb. f. Min. u.s.w. 1851, p. 181–2.]

In a letter to Dr. K. C. v. Leonhard, the author states that in a short memoir on the Internal Structure of Mountains, lately published at Freiberg, he has attempted the physiology, as it were, of mountains, in showing the different phases of their formation and destruction. The chief results arrived at are—

1. The mountains did not suddenly arise, but were formed by degrees, sometimes during very long periods of time.

2. For their position and direction there are as yet no general laws positively known.

3. All true mountains are results of elevatory volcanic (plutonic) action.

4. The majority, however, in their present form are at the same time the result of a later destructive process (the action of water) in very unequal degrees.

5. The mountain-elevations are to be distinguished as local from the continental elevations of great tracts of land, which latter may be bare swellings, unless eruptive rocks find a local vent.

6. Horizontal forms of the mountains correspond in some degree to the grouping of the volcanos,—the single mountain-masses (*Massen-Gebirge*) to the central volcanos (*Vulkan-Gruppen*), the mountain-chains to the lines of volcanos (*Vulkan-Reihen*).

7. Of the origin of mountains the author distinguishes three principal kinds, and very many forms of combination, and stages of development and destruction. The three kinds of origin are:—

a. By the efflux and superficial accumulation of eruptive rocks;—volcanic mountains.

b. By the elevation of existing hard portions of the earth's crust, caused by eruptive rocks penetrating upwards;—plutonic mountains.

c. By lateral pressure, and, in consequence thereof, the folding of existing hard portions of the earth's crust.

8. Several of these kinds of development, however, sometimes occur in combination with one another.

9. The mountains originating in the elevation of the existing hard portions of the earth's crust, owing to the upward pressure and penetration of eruptive masses, exhibit the most manifold diversity of stages of destruction, whereby they fall into mountains with folded strata [Falten-Gebirge], crystalline slate mountains, and central mass mountains of upper, middle, and lower section.

10. The mountains with folded strata of this sort, however, are not always distinguishable from those originating in lateral pressure.

11. Of especial importance in judging of the relative age of the mountains,—besides the distinction of elevated and non-elevated beds brought forward by E. de Beaumont,—is the fixing of the mountain-chains as lines of separation between deposits during determined periods;—recognizable by dissimilar characters in the series of sedimentary formations on two or more sides.

12. The volcanic mountains are distinguished from the plutonic, consolidated within the earth, both by their external form and by their mineralogical conditions. The first form superficial, the second form subterranean cones of eruption. The section of these last exhibits (for example) the so frequently referred to granite-ellipsoids. Both, however, fill up also narrower fissures, in which they are then mostly crystallized somewhat otherwise than in the great principal masses.

[T. R. J.]

On some Fossils *from the* Lower Chalk Formation *of the* Cape of Good Hope. By Prof. Dr. F. Krauss.

[Nova Acta Acad. C. L. C. Nat. Cur. vol. xxii. part 2. 1850, pp. 439–464.]

In April 1839 the author made an excursion from Uitenhage, which lies near the Kaffir boundary and only a few leagues from Algoa Bay, along the left bank of the Zwartkops River, as far as its mouth, and met with fine sections of fossiliferous strata, probably belonging to the Lower Greensand.

In a communication made by Dr. Krauss in 1842 to the Meeting of German Naturalists and Physicians at Mayence*, he made mention of this formation, and exhibited the fossils found in it; and in this memoir† he now gives detailed descriptions of the same, illustrated by four quarto lithographed plates.

The occurrence of this formation, says the author, is so much the more remarkable, as along the whole seaboard from Table Bay‡ to Algoa Bay, nearly through eight degrees of longitude, nowhere does a trace of it occur. I have crossed this tract of the coast as far as Karroo in all directions, and always found on the heights of variegated sandstone, in the valleys and plains of clay-slate or greywacke-slate, rare beds of a sandstone-conglomerate or intrusive granite. Even on the Zwartkops River Heights, near Uitenhage, the greywacke occurs, and on the neighbouring Van Stadenberg the sandstone.

In descending, however, the bed of the above-mentioned river, we are soon struck by a vegetation remarkably different from that of the other districts, and still more astonished by the beds of colossal *Trigoniæ*, perfect specimens of which, washed out by the water, lie exposed in many places.

As far as I could examine the extent of this basin, I found it to reach from the salt-lakes between Uitenhage and Port Elizabeth, along the Zwartkops River below Uitenhage, and partly on the Koega River, as far as the Zondag [Sunday] River§, in a circuit of several leagues.

About one and a half league below Uitenhage I found close to the left bank of Zwartkops River a very fine section of a mass of Green-

* Amtl. Bericht, p. 126. † Communicated to the Academy in April 1847.

‡ See Map of the Cape Colony, accompanying Mr. Bain's Paper on the Geology of the Albany District, Trans. Geol. Soc. vol. vii. Pl. 2.

§ These three rivers, running parallel with each other from N.W. to S.E., empty themselves into Algoa Bay. Sunday River is the most easterly, and Zwartkops River, on which Uitenhage is situated, is the most westerly.

sandstone, 20–24 feet* in thickness, on the horizontal beds of which lay an undulating bed of gravel of variegated sandstone from 6 to 7 feet thick. Here, and especially in the bed of the river, occurred *Lyrodon Herzogii* and *L. conocardiiformis* in such perfection as I have nowhere else seen, and in so great profusion that some beds were nearly altogether composed of these shells. This formation, however, has a still more extensive development lower down the river, in the neighbourhood of H. Buckenröder's residence.

A stratum, 4 feet thick, which especially contains both species of *Lyrodon*, but mostly in a worn and imperfect condition, here also forms the base; and resting on it in the following order are:—

	feet.	in.
Hard Greensandstone, coloured by its contained iron, fossiliferous in its lowermost beds, about	60	0
Weathered Greensandstone	10	0
Hard, alternating in thin beds with weathered, Greensandstone	6	0
Greensandstone, coloured by iron and fossiliferous	1½	0
Weathered Greensandstone	15	0
Hard Greensandstone, but without fossils	1	4
Hard ferruginous Greensandstone, very rich in fossils, among which *Astarte Herzogii, Exogyra imbricata, Anoplomya lutraria,* and *Lyrodon ventricosus* are particularly abundant	1	6
Loam and weathered rock	12	0
Gravel of variegated sandstone, for the most part cemented into a loose conglomerate by newer marine limestone	6 to 30	0

The stone of the lower fossiliferous beds is tolerably hard, greyish, sometimes greenish, very rich in fragments of shells, all of which, as well as the perfect shells, are changed into calc-spar, or, if the rock be loose and crumbly, they are white, and as it were calcined. In these beds we find *Lyrodon Herzogii, L. conocardiiformis, L. ventricosus,* a *Mytilus* with a sharp keel running from the umbo to the hinder extremity and a truncated flat surface from this keel to the ventral border, a *Pinna,* two species of *Ostrea,* one of which is strongly ribbed, the other smooth and laminated, and some other smaller undetermined bivalves.

The stone of the upper fossiliferous beds is hard, coloured reddish-grey by oxide of iron, and likewise rich in shell-fragments, which, together with the perfect shells, have usually a red-brown colour. In these beds occur *Astarte Herzogii, A. Bronnii, Anoplomya lutraria, Exogyra imbricata, Lyrodon ventricosus, Cucullæa cancellata, Gervillia dentata,* a *Natica*?, and some undetermined bivalves.

A rock somewhat different from those just described occurs in the neighbourhood of the Salt-lakes, one of which lies between the Zwartkops and the Koega Rivers, at about 150 feet above the sea, the other between Uitenhage and Port Elizabeth, at about 30 to 40 feet above the sea. This rock is very small in quantity, at the latter place only 3 to 4 inches thick, dirty grey, quartzy and

* German measurements are retained in this translation.

therefore hard, and extremely rich in small, mostly crushed shells, which have usually the appearance of having been calcined. The fossils, as far as their condition allows of determination, are:—of Molluscs, *Dentalium*, *Turritella*, *Ostrea*, *Nucula*, and probably a small *Astarte*; of Echinoderms, a *Cidarites*, of which, however, I found only one spine, covered with small granulations. On these fossiliferous beds, as on the Zwartkops River, lies a light, friable, grey sandstone, 20 feet thick, in which there are not any fossils, alternating with beds (one foot thick) of a reddish-grey, rather heavy rock, frequently dividing into nodules, that I took for Sphærosiderite. Of the great Ammonites and remarkable Hamites, mentioned by Hausmann*, I have nowhere found a trace; perhaps they occur in the neighbourhood of the Zondag River. This formation does not appear to extend further to the east of this river, since the hills in the vicinity have altogether the form of the other sandstone hills of the colony, and the high ground between the Zwartkops and the Koega Rivers, the Tweekoppen, is really occupied, as I have convinced myself, by the usual quartzose variegated sandstone.

In describing this peculiar district I must allude to the fact, that on the Grass Ruggens, near the Zondag River, is the Schulpen-gat [Shell-pit], already referred to by Hausmann and by myself at Mayence; here, under a bed of white marine limestone, scarcely half a foot thick, is a deposit of innumerable Oyster-shells, which the colonists use for lime-burning: and also to the existence on the right bank of the Koega River, about four leagues from Uitenhage, of a remarkably carbonated chalybeate spring, of 31° C., a detailed account of which I gave in Leonhard and Bronn's Jahrb. f. Min. &c., 1843, p. 161.

A description follows of nine species of Molluscs. The new genus *Anoplomya* is described as having the form of a *Lutraria*, but without hinge-teeth; it is grouped with the *Myacea*, and thus characterized:—

Testa transversa, inæquilateralis, æquivalvis, hians. Dentes nulli. Margo cardinalis tenuis (non callosus), biplicatus, inter marginem umbonesque foveolatus. Umbones a margine cardinali distantes. Ligamentum externum.

The author gives figures of the following:—

Anoplomya lutraria, nov. gen. sp.
Astarte Herzogii, *Krauss*.
Cytherea Herzogii, *Hausm*.
Astarte Capensis, *Krauss*, 1843.
Astarte Bronnii, n. sp.
Cucullæa cancellata, n. sp.
Lyrodon Herzogii, *Hausm*., *Goldf*.
—— conocardiiformis, n. sp.
—— ventricosus, n. sp.
Gervillia dentata, n. sp.
Exogyra imbricata, n. sp.

[T. R. J.]

* Götting. gelehrt. Anzeig. 1837, p. 1449. [Mr. Bain mentions the finding of an Ammonite (*Am. planatus*?) *in situ* on the summit of the Spitzkop (*loc. cit.* p. 57), near Graaff Reinet and N.N.W. of Uitenhage. Some specimens of *Ammonites* and *Nautili* (accompanied by two or more species of *Lyrodon* and other fossils), from the neighbourhood of the Sunday River, were presented in 1849 to the Geological Society of London by Dr. Atherstone.—Transl.]

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. VII.

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