LONDON GEOLOGICAL SOCIETY

QUARTERLY JOURNAL

13

1857

TABLE OF CONTENTS.

PART I.—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.
ZOOPHYTA. (3.)			
Flustrellaria dentata. Pl. ii. f. 2	Chalk	Aberdeenshire ...	86
Hippothoa Voigtiana. Pl. vii. f. 14, 15	Permian	Durham	217
Semiescharipora mumia. Pl. ii. f. 1...	Chalk	Aberdeenshire ...	86
ANNELIDE. (1.)			
Arenicolites sparsus. Pl. v. f. 2–4 ...	Cambrian ...	Longmynd	203
ECHINODERMA. (1.)			
Toxaster, sp. Pl. ii. f. 4...............	Up.Greensand	Aberdeenshire...	86
MOLLUSCA. (12.)			
Ammonites, 2 sp. Pl. ii. f. 9 & 10 ...	Up. Greensand	Aberdeenshire ...	87
Avicula simulata. Pl. ii. f. 5	Up. Greensand	Aberdeenshire ...	86
Chemnitzia Roessleri. Pl. vii. f. 8 ...	Permian	Durham	216
Chiton Howseanus. Pl. vii. f. 9–13...	Permian	Durham	216
—— Loftusianus. Pl. vii. f. 9	Permian	Durham	216
Cyprina Fergusoni. Pl. ii. f. 7	Up. Greensand	Aberdeenshire ...	87
Dentalium cœlatulum. Pl. ii. f. 8 ...	Up. Greensand	Aberdeenshire ...	87
Lima elegans. Pl. ii. f. 3..............	Chalk	Aberdeenshire ...	85
—— Permiana	Permian	Durham	217
Limopsis texturata. Pl. ii. f. 6	Up. Greensand	Aberdeenshire ...	86
Pectunculus umbonatus?	Up. Greensand	Aberdeenshire ...	86
CRUSTACEA. (9.)			
Acidaspis callipareos. Pl. vi. f. 11, 12	Lower Silurian	Ayrshire...........	208
—— Caractaci. Pl. vi. f. 15–17	Caradoc sandstone.	Gretton	211
—— *coronata*	Lower Ludlow	Ludlow	210
—— *Hystrix.* Pl. vi. f. 6–10	Lower Silurian	Ayrshire...........	207
—— *Lalage.* Pl. vi. f. 1–5	Lower Silurian	Ayrshire...........	206
—— *unica.* Pl. vi. f. 13, 14	Lower Silurian	Ayrshire...........	209
Goniodactylus (recent). Pl. xiii. f. 6.	....	....	368
Mysis (recent). Pl. xiii. f. 4, 5	....	....	368
Prosoponiscus problematicus. Pl. vii. f. 1–7.	Permian	Durham	214
Pygocephalus Cooperi. Pl. xiii. f. 1–3	Coal-measures	Manchester	363
Tropifer lævis. Woodcuts	Lias Bone-bed	Aust-Passage	361

EXPLANATION OF THE PLATES.

ERRATA.

Page 97, in the 4th column of the Table, *for* 1 1 *read* 141.
,, 317, line 29 from the top, *for* molars *read* incisors.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEBRUARY 20, 1857.

REPORT OF THE COUNCIL.

THE Council, in submitting their Annual Report to the Members, have pleasure in being able to bear testimony to the generally prosperous state of the Society. The deaths and resignations have been considerable during the last year, though not so high as in the previous year. Twenty-four new Fellows have been elected, and two, who were elected in the previous year, have paid their subscriptions, making an addition of twenty-six ordinary Fellows. One Foreign Member has also been elected. On the other hand, the diminution which the Society has sustained from deaths is twenty-two, and by resignation seven, amounting to twenty-nine; and two Fellows have been removed as defaulters; and by deducting one Non-Resident Fellow, who was considered in 1855 as deceased in error, it makes a decrease of thirty ordinary Fellows. Two Foreign Members have died, as also two Honorary Members. The total number therefore of the Geological Society at the close of 1855, was 875, and at the close of the past year it consisted of 868 Members.

The Council have to report that the expenditure during 1856 has exceeded the income by £183 1*s.* 10*d.*, which does not include the sum of £79 12*s.* 4*d.*, the amount of excess of expenditure at the close of 1855: the actual excess of expenditure is therefore £280 14*s.* 2*d.*: this circumstance is chiefly to be explained by the payment of £102 5*s.* 0*d.* for the Supplementary Catalogue, and by the expense of the completion of the 7th Volume of the Transactions (publications which are not likely soon to recur), and the expenditure of about £30 connected with the late Mr. Greenough's bequest, which will hereafter be liquidated from his special legacy.

The amount of the Funded Property of the Society remains the same as at the close of 1855, viz. £4578 19*s.* 2*d.*; but of this £500 is temporarily invested until required to defray the expenses of providing accommodation, &c. for the collections of the late Mr. Greenough, which sum was bequeathed by him for that especial object. The Society also holds two Exchequer Bills of £100 each.

The Society have to deplore the loss of Mr. Daniel Sharpe, who was elected only at the last Anniversary Meeting, President of the Society for the past year. His death occurred in May last, and his brother, Mr. Henry Sharpe, as his representative, requested the acceptance by the Society of his lamented brother's collection of fossil shells contained in three Mahogany Cabinets, as well as his valuable collection of Farringdon, Tourtia, Pisolitic limestone, and North American Fossils, together with several valuable books, as specially mentioned in the annexed Report of the Library and Museum Committee.

Amongst other donations received since the last Anniversary, the Council would call attention to the valuable Maps, coloured Geologically, of six of the French Departments, consisting of several sheets (some accompanied with letter-press), which were presented, through the British Ambassador, by the Minister of the Interior of France.

The Council have to report that the 12th volume of the Quarterly Journal has been completed; and that the 1st part of volume 13th will shortly appear.

The Council have also to state that the 4th Part of the 7th volume of the Transactions has been published, as well as the Supplementary Catalogue of the Library.

They have further to report that a temporary engagement has been made with Mr. W. Whitaker, to assist in the Museum and Library; and the Council would especially direct the attention of the Fellows to that portion of the annexed Report of the Library and Museum Committee, in which a hope is expressed that Fellows of the Society will offer their services to assist in the arrangement of numerous collections, which, for want of such aid, must continue unavailable for the promotion of Science.

In conclusion the Council beg to state, that they have unanimously awarded the Wollaston Palladium Medal to M. Joachim Barrande of Prague, Member of the Geological Society of France, and Foreign Member of the Geological Society of London, for his eminent services in developing the true history of the lower Palæozoic rocks, and particularly for his great work the "Système Silurien de la Bohême," in the preparation of which, at heavy pecuniary cost, he has evinced such a union of zealous researches in the field with the profoundest knowledge in palæontology, as to have obtained for him the admiration of his contemporaries.

They have also awarded the balance of the proceeds of the Wollaston Donation Fund to Mr. S. P. Woodward, for his Manual of the Mollusca, recent and fossil, and to assist him in the preparation of a similar work on the Radiata.

Report of the Library and Museum Committee.

Library.

The bequest of upwards of 1150 volumes, besides Pamphlets, Maps, and Plates, to the Society by the late G. B. Greenough, Esq., was referred to in last year's Report.

Of these books about 250 have been arranged on the Library-shelves in place of the Society's copies of the same works, in accordance with the suggestions of the Committee appointed for the disposition of Mr. Greenough's Bequest. About sixty other volumes have been retained as Duplicates of works already in the Library, and of which it is desirable to keep a second copy. About 540 volumes have been selected as works new to the Library.

Without reckoning Pamphlets, there is therefore an accession, from this source, of about 600 volumes to the Society, and a replacement of about 250 volumes on the shelves by, for the most part, better copies.

The remaining Duplicates of Mr. Greenough's Books, together with the volumes removed from the Library-shelves, have been disposed of under the care of the Special Committee above referred to, and are in course of distribution in the following manner: to the Royal Geographical Society thirty volumes: to the Geological Survey 150 volumes: to the University College 260 volumes. About 110 duplicates still remain for distribution.

In the Society's Library there are about 100 duplicate volumes of works not in request, and which it would be desirable to part with to obtain space on the shelves. These Duplicates might be conveniently distributed in the same manner and at the same time as the Duplicates of Mr. Greenough's Bequest.

A valuable gift of Books has been made to the Society during the past year by Henry Sharpe, Esq., who has presented thirty works from the Library of our late lamented President, Daniel Sharpe, Esq., and a nearly complete series of separate copies of Mr. D. Sharpe's published papers.

Mr. Henry Sharpe's gifts, and the other presents of books and periodicals since the last Anniversary, have been arranged in their places in the Library, and for the most part bound as far as is necessary.

The majority of Mr. Greenough's books are not yet permanently arranged on the shelves; and are as yet only catalogued in manuscript.

Considerable labour will be required to complete the necessary arrangement of books, both in the Library and on the supplemental shelves in the Assistant-Secretary's Room, and on those lately erected in the Meeting Room in accordance with the suggestion of the above-mentioned Committee.

The very large and important collection of Geological Maps bequeathed by the late G. B. Greenough, Esq., have been catalogued in manuscript and have been placed in geographical order in the

Cabinet-table constructed for that purpose, and placed in the Lower Museum, as recommended by the Committee appointed to consider the arrangement of the Books and Maps bequeathed by Mr. Greenough.

The mounting on cloth of such maps as are likely to be required for frequent reference, including the sheets of the Geological Survey Map and Sections, has been continued as usual. It is desirable that, to avoid complexity and delay, the mounting of such maps should be placed on the same footing as the Binding of Books, and be proceeded with when found necessary by the Assistant-Secretary.

The new Table-case for Charts and Maps placed in the Lower Museum in 1855 is now quite filled. The vacancies also in the other Map-cases, caused by the removal of sundry Maps ordered in 1853 to be mounted and placed in pasteboard Map-cases for easy reference, have been filled up ; and more case-room will be required before long for Maps and Charts.

The "Supplemental Catalogue of the Books, Maps, Sections, and Drawings" has been completed and published. It comprises all the Periodical Works in the Library to the end of 1853, and the additions of Books to the same date. The lists of Maps, Charts, and Drawings comprise accessions of still later date, as explained in the Preface to the "Supplement."

The Committee particularly wish to draw attention to the Geological Sections, Plans, Views, &c., the Drawings of Fossils, and the Portraits, which are in the Society's Portfolios, and are now for the first time catalogued and published. These lists not only offer useful materials for the working geologist, but will serve as nuclei for further contributions of similar valuable documents, which, even if preserved in private collections, often lie disregarded and of no avail to scientific observers.

The Committee recommend that the numerous titles of Books received of late years, including those of Mr. Greenough's Bequest, be written out fairly in alphabetical order in the Library Catalogue kept for facility of reference to the books on the shelves. And that the list of additional Maps be also distinctly written out in the Map Catalogue of reference kept in the Lower Museum. This incorporation of the additional Titles will be well worth the extra expense of the temporary labours of a copying clerk.

Museum.

A Collection of Fossil Mollusca, contained in three large mahogany cabinets, and arranged zoologically,—also several suites of special Fossils and Geological specimens, including a valuable series of Palæozoic Fossils from North America,—have been presented by Henry Sharpe, Esq., from the Collection of his late brother, Daniel Sharpe, Esq., Pres. G.S.

The above-mentioned Collection of Fossil Mollusca has been carefully arranged, under Mr. Jones's direction, and according to the classification adopted in Mr. Woodward's "Manual," by Mr. W.

Whitaker, who gave his voluntary aid to the Assistant-Secretary in the summer of last year for this purpose. A list of the Contents, indicating the genera and subgenera, has been also prepared by Mr. Whitaker.

Mr. Whitaker has also newly arranged the recent shells in the Society's Library, and the Series of Paris Tertiary Shells in the Upper Museum, according to Mr. Woodward's classification.

The materials for a special series of Rock-specimens, mineralogically arranged, have been put together by Mr. Pratt, who has also commenced their arrangement, and will proceed with this desirable Collection as his leisure and opportunities permit.

The Collection of simple Minerals (in the Society's Library) has been enriched, through the liberality of Mr. Wheatley of New York, by a beautiful series of lead and zinc ores from the Wheatley Mines, Pennsylvania.

The additions to the Lower Museum—or Collection of British Fossils—have not been numerous during the past year.

The Foreign Collections, however, in the Upper Museum, have received valuable additions of Fossils and other specimens from Greece, Turkey in Asia, India, Sarawak, Australia, Owhyhee, Namaqualand, and other localities. Nearly all of these have been placed in their respective drawers.

The extensive and valuable Collection of Plants and other Fossils from Nagpoor still remains undescribed; and the Prome Fossils, also alluded to in last year's Report, have not attracted the attention which is due to them from working palæontologists.

Indeed a wide and attractive field is open to Fellows of the Society, who may have the requisite leisure and zeal, for the study, arrangement, and description of the great stores of foreign materials which the Society's Museum presents. The Nagpoor Series, however, has a prior claim to attention both on account of its being the necessary illustration of Messrs. Hislop and Hunter's Memoir already published in the Society's Journal, and as a sequel to Dr. Malcolmson's Memoir on the same region in the Transactions.

As the Assistant-Secretary is already overburthened with his multifarious duties, and as the funds of the Society do not admit of paying for this labour, even if the adequate knowledge could be purchased, the Committee hope that the zeal of some Fellows of the Society will induce them to offer their services to the Council for this important object; whereby they cannot fail greatly to advance the interests of Geological Science.

The latest result of such voluntary labour in the Museum was the working out, by Mr. D. Sharpe, Mr. Salter, and others, of the South African Fossils, which are now arranged in the Upper Museum according to their descriptions in the 4th part of the 7th volume of the Transactions lately published.

The interleaved copy of Mr. Morris's "Catalogue of British Fossils" placed in the Lower Museum to serve as the means of cataloguing the British Collection, in accordance with an order of Council in 1855, has not received further entries beyond those made by the late Mr. D. Sharpe and Mr. S. V. Wood, as noticed in the last Report. If the plan on which this Catalogue was commenced were carried out, the Society's Collections would be rendered much more available.

Mr. Jones reports, that during the time that Mr. Whitaker has been assisting him, in accordance with the order of Council granting this temporary assistance, he has been gratified by Mr. Whitaker's willingness and attention, and has been greatly aided by him in general business and in the arrangement of Books, Maps, Charts, and Specimens. The Committee think that there is ample material for the continued useful employment of Mr. Whitaker's labours.

The Assistant-Secretary has laid before the Committee a series of sorted specimens of Foraminifera and Bryozoa, picked from some of the sandy and clayey matrices of fossils from Palermo, Turin, and San Domingo in the Society's Collection, and mounted on small mahogany slides, by W. K. Parker, Esq., who offers to sort out and arrange in a similar manner all the Foraminifera, &c. (including the Society's extensive series of Nummulites) which may be found in the Collection, if the Society will bear the trifling expense of the materials for the slides and a few boxes or drawers for such as will have to be placed in racks.

The Committee have been highly gratified with the beautiful series of specimens thus presented to them, and strongly recommend the acceptance of Mr. Parker's liberal offer of assistance in the arrangement and mounting of these minute and interesting fossils.

Leonard Horner.
W. W. Smyth.
S. R. Pattison.
Thomas F. Gibson.

Comparative Statement of the Number of the Society at the close of the years 1855 *and* 1856.

	Dec. 31, 1855.		Dec. 31, 1856.	
Compounders		131		128
Residents		201		189
Non-residents		474		485
		806		802
Honorary Members	15		13	
Foreign Members	50		49	
Personages of Royal Blood	4	—69	4	—66
		875		868

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1855 *and* 1856.

Number of Compounders, Residents, and Non-residents, December 31, 1855			806
Add, Fellows elected during former years, and paid in 1856	Residents ..	2	
Fellows elected, and paid, during 1856	Residents .. 7 Non-residents 17	—24	
		—	26
			832
Fellow erased in error as deceased, 1855, Non-resident			1
			833
Deduct, Compounders deceased		4	
Residents ,,		5	
Non-residents ,,		13	
Resigned		7	
Removed		2	
		—	31
Total number of Fellows, 31st Dec. 1856, as above			802
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1855			69
Add, Foreign Member elected during 1856			1
			70
Deduct, Honorary Members deceased		2	
Foreign Members ,,		2	
		—	4
	As above		66

Number of Fellows liable to Annual Contribution at the close of 1856, *with the Alterations during the year.*

Number at the close of 1855		201
Add, Elected in former years, and paid in 1856		2
Elected and paid in 1856		7
		210
Deduct, Deceased	5	
Resigned	5	
Compounded	1	
Removed	2	
Became Non-resident	8	
	—	21
As above		189

Deceased Fellows.

Compounders (4).

N. Larkin, Esq.
Sir B. F. Outram.
William Richardson, Esq.
Daniel Sharpe, Esq.

Residents (5).

Samuel Clegg, Jun., Esq.
William Evans, Esq.
Dr. D. Finlay.
John Kenyon, Esq.
James Loch, Esq.

Non-residents (13).

Very Rev. W. Buckland, D.D.
Sir Alexander Crichton.
R. Fothergill, Esq.
J. B. Fraser, Esq.
Archdeacon Hare.
Rev. Thomas Image.
Lieut.-Col. Lloyd.
Rev. John Lodge.
Rev. Dr. Lyon.
Lt.-Col. Sir T. L. Mitchell.
R. J. Nevill, Esq.
C. H. Turner, Esq.
S. Woolryche, Esq.

Honorary Members (2).

L. W. Dillwyn, Esq.
Dr. A. Ure.

Foreign Members (2).

M. J. de Charpentier.
Prof. Constant Prévost.

The following Persons were elected Fellows during the year 1856.

January 9th.—Henry Philip Hakewill, Esq., Harrington Square, Hampstead Road.

—— 23rd.—Richard S. Roper, Esq., Abercarn; and Rev. Samuel Lucas, Bryn Mawr, Monmouthshire.

February 6th.—Rev. Thomas Wiltshire, M.A., Rectory, Bread Street Hill.

—— 20th.—William Howland Roberts, M.D., Markham Square, Chelsea.

March 5.—Herbert George Bowen, Esq., Gower Street, Bedford Square; Thomas Moffat, M.D., Hawarden, near Chester; Prof. Henry Benedict Medlicott, A.B., Roorkee, Bombay; William H. Groser, Esq., Hemingford Villas, Barnsbury Park; William Mathews, jun., Esq., B.A., Edgbaston, Birmingham; Joseph Walter Tayler, Esq., Arksut, Greenland; and Thomas James Smith, Esq., Whitefriargate, Hull.

March 19th.—Capt. Walter S. Sherwill, Bengal; Daniel Thomas Evans, Esq., Temple; and Rev. Henry Hayton Wood, M.A., Oxford.

April 9th.—Thomas Henry Huxley, Esq., Government School of Mines.

—— 23rd.—Lester Lester, Esq., Langton Maltravers, Dorset.

June 4th.—Ernest Powell Wilkins, Esq., Newport, Isle of Wight.

November 5th.—George Brand, Esq., M.A., Angola, Africa; and R. Brough Smyth, Esq., Melbourne, Victoria.

—— 19th.—William Downing Biden, Esq., Gresham Street.

December 3rd.—John Gifford Croker, M.D., Bovey Tracey; Rev. Edward Francis Witts, Upper Slaughter, Stow-on-the-Wold; Rev. Edward Duke, Salisbury; G. P. Bevan, M.D., Beaufort, Newport, Monmouthshire; Rev. J. B. P. Dennis, Bury St. Edmunds; and Capt. P. D. Margesson, Woolwich.

—— 17th.—Richard Edward Arden, Esq., Sunbury Park; and William Bullock Webster, Esq., Neath, S. Wales.

The following Person was elected a Foreign Member.

March 5th.—Prof. Rudolph Bunsen, Heidelberg.

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

British Specimens.

Specimen of Cleveland Iron-ore; presented by A. Dick, Esq.

Specimens from the Keuper of Warwickshire; presented by the Rev. P. B. Brodie, F.G.S.

Specimens of Altered Syenite from the Malverns; presented by the Rev. W. Symonds, F.G.S.

Specimens of Kimmeridge Coal; presented by E. W. Jackson, Esq., F.G.S.

Foreign Specimens.

Specimens of Fossil Shells from Melbourne; presented by J. Trapp, Esq.

Plants and other Fossils from the Nagpur Territory; presented by the Rev. Mr. Hislop.

Specimens of Lava from Owhyhee; presented by the Foreign Office.

Specimens of Rocks, &c. from Trinidad; presented by H. G. Bowen, Esq., F.G.S.

Specimens from Soochow, China; presented by Daniel Hanbury, Esq.

Specimens from Varna, the Dardanelles, and the Grecian Archipelago; presented by Capt. T. A. B. Spratt, F.G.S.

Lignite and Shells from Erzeroum; presented by Major R. J. Garden.

Specimens from Sarawak; presented by R. Coulson, Esq.
Minerals from Wheatley Mine, Pennsylvania; presented by C. M. Wheatley, Esq.
Copper Ores and other Minerals from Siam; presented by the Foreign Office.
Copper Ores, &c. from the Mines of Namaqualand; presented by Dr. Rubidge.

Collection and Cabinets belonging to the late Daniel Sharpe, Esq., Pres. G.S.; presented by Henry Sharpe, Esq.

Charts and Maps.

Forty-nine Charts published by the Dépôt de la Marine; presented by the Director-General of the "Dépôt de la Marine."
Sheets 16 and 17 of the Geological Survey of Great Britain, and Index to Colours and Signs employed; presented by the Director-General of the Geological Survey of Great Britain.
Carte Géologique du Département de Maine et Loire, du Morbihan, de la Flandre Française, de Cher, and Sections; presented by the Minister of Public Works of France.
Geological Map of Bengal, by Capt. W. S. Sherwill, 1853, and View of Darjeeling, in 1852; presented by the Author.
Geological Map of the United States and British North America, by Prof. H. D. Rogers, 1855, and the Arctic Basin, its limits, features, drainage, currents, &c.; presented by the Author.
Geological Map of Europe, by Sir R. I. Murchison and James Nicol, in 4 sheets; presented by Sir R. I. Murchison, F.G.S.
Carte Géologique des États-unis et des provinces anglaises de l'Amérique du Nord, par Jules Marcou; presented by the Author.
A general Map of Ireland, showing the principal Physical Features and Geological Structure of the country, in 6 sheets, by Richard Griffith; presented by the Author.
Mappa Geologico d'America do Sul; presented by Herr W. Haidinger.
Geographical Map of the Republic of Nicaragua, by Fermin Ferrer, 1855; presented by the Author.
Map of the Boundary between the United States and Mexico, 1855; presented by the Smithsonian Institution.
Geological Map of England and Wales, by Sir R. I. Murchison, 3rd edition, 1856 (2 copies); presented by the Author.
Geological Map and Sections of the Islands of Malta and Gozo (3 sheets); presented by the Ordnance Office.
Map of the Geology and Contours of London (on rollers), by R. W. Mylne; presented by the Author.

Geological Section of the Line of Inland Navigation from Bristol to London; presented by Sir Charles Lyell, V.P.G.S.

Miscellaneous.

Model, illustrative of Dr. Leeson's System of Crystallography; presented by J. R. Larkin, Esq.
Photographic Portraits of D. Sharpe, Esq., Sir P. G. Egerton, Sir R. I. Murchison, and Prof. Ansted; presented by Messrs. Maull and Polyblank.
Lithographic Portrait of Karl Haidinger; presented by Herr W. Haidinger.
Engraved Portrait of Playfair, in glazed frame; presented by L. Horner, Esq., F.G.S.
Medal in Honour of Hofrath Haidinger; presented by his Friends.

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.

Abich, Herr H.
American Academy of Arts and Sciences.
American Philosophical Society.
Art Union of London.
Ashmolean Society.
Asiatic Society of Bengal.
Asiatic Society of Great Britain.
Athenæum Journal, Editor of the.

Babbage, C., Esq.
Barrande, M. J., For.M.G.S.
Basle, Natural History Society of.
Berlin, German Geological Society at.
Berlin, Royal Academy of Sciences at.
Blofeld, J. H., Esq., F.G.S.
Blyth, Prof. J.
Bombay Geographical Society.
Boston Natural History Society.
Bowen, H. G., Esq., F.G.S.
Breslau Academy.
British Association for the Advancement of Science.
Brodie, Rev. P. B., F.G.S.
Bryce, J., Esq., F.G.S.

Canadian Journal, Editor of the.
Carpenter, W. B., M.D., F.G.S.
Catullo, Prof. T. A.
Charleston (South Carolina) Society of Natural History.
Chemical Society of London.
Cherbourg, Société Impériale des Sciences Naturelles de.
Cincinnati, Young Men's Mercantile Library Association of.
Civil Engineers' Journal, Editor of the.
Cocchi, M. J.
Commissioners of Her Majesty's Works, &c.
Copenhagen, Royal Society of.
Coulson, R., Esq.
Critic, Editor of the.
Croker, Dr., F.G.S.

Dana, Prof. J. D., For.M.G.S.
Daubeny, Prof., M.D., F.G.S.
Davidson, Thomas, Esq., F.G.S.
Delesse, M. A.
Dennis, Rev. J. B., F.G.S.
Deslongchamps, M. E.
Dick, A., Esq.
Dickson, S., M.D.
Dijon, Academy of Sciences of.
Dublin Geological Society.

East India Company, The Hon.
Egerton, Sir P. G., Bart., M.P., F.G.S.

Elliot Society of Natural History, Charleston.
Erdmann, Herr A.

Faraday, M., D.C.L., F.G.S.
Favre, M. A.
Ferguson, W., Esq., F.G.S.
Ferrer, M. Fermin.
Foreign Office.
France, Geological Society of.
France, Minister of Public Works of.
Franklin Institute of Pennsylvania.

Garden, Major R. J.
Gaudin, M. M.
Geinitz, Dr. Hans Bruno.
Genève, Société de Physique et d'Histoire Naturelle de.
Geological and Polytechnic Society of the West Riding of Yorkshire.
Geological Survey of the United Kingdom.
Goebel, Herr von A.
Great Exhibition of 1851, Commissioners of the.
Griffith, R., Esq., F.G.S.
Guiscardi, Signor G.

Haidinger, Herr W., For.M.G.S.
Halle Society of Natural History.
Hanbury, D., Esq.
Harkness, Prof., F.G.S.
Harlem, Société Hollandaise des Sciences de.
Hauer, Herr F. R. v.
Haughton, Rev. Prof. S., F.G.S.
Hausmann, Prof. J. F. L., For. M.G.S.
Helmersen, Colonel G. von, For. M.G.S.
Hennessy, Prof. H.
Henwood, W. J., Esq., F.G.S.
Hislop, Rev. S.
Holmes, Rev. J. I.
Hopkins, E., Esq., F.G.S.
Hopkins, W., Esq., F.G.S.
Horner, G. R. B., M.D.
Horner, L., Esq., F.G.S.

Indian Archipelago Journal, Editor of the.
Institute of Actuaries.

King, Prof. W.
Kjerulf, Herr T.

Lancashire and Cheshire Historic Society.
Larkin, J. R., Esq.
Lea, I., LL.D.
Leeds Philosophical Society.
Liége, Société Royal des Sciences de.
Linnean Society.
Literary Gazette, Editor of the.
Liverpool Literary and Philosophical Society.
Loftus, W. K., Esq., F.G.S.
Logan, J. R., Esq., F.G.S.
Lyell, Sir Charles, F.G.S.

Madrid Royal Academy of Sciences.
Manchester Philosophical Society.
Marcou, M. Jules.
Marianini, Signor P. D.
Martins, M. Ch.
Maull and Polyblank, Messrs.
Meugy, M. A.
Microscopical Society.
Middle Rhine Geological Society.
Modena, Italian Society of Science of.
Morris, Prof. J., F.G.S.
Mortillet, M. G. de.
Murchison, Sir R. I., F.G.S.
Mylne, R. W., Esq., F.G.S.

Newbury, J. T., M.D.

Oldham, T., Esq., F.G.S.
Omboni, M. J.
Oppel, Dr. A.
Ordnance, Board of.
Owen, Prof., F.G.S.

Paris, Academy of Sciences of.
Paris, École des Mines de.
Paris, M. le Directeur-Général du Dépôt de la Marine de.
Paris, Muséum d'Histoire Naturelle de.
Payot, M. V.
Perrey, M. A.
Philadelphia Academy of Natural Sciences.
Photographic Society.
Pictet, Prof. F. J.
Poole, R. S., Esq.
Pring, J. D., Esq.
Puy, Société d'Agriculture, Sciences, Arts et Commerce du.

Quenstedt, Herr F. A.

Raulin, M. V.
Ray Society.
Redfield, W. C., Esq.
Reeve, L., Esq., F.G.S.
Renevier, M. E.
Rennie, G., Esq., F.G.S.
Roemer, Dr. Ferd.
Rogers, Prof. H. D., For.M.G.S.
Royal Academy of Munich.
Royal Astronomical Society.
Royal College of Surgeons.
Royal Dublin Society.
Royal Geographical Society.
Royal Institution of Cornwall.
Royal Institution of Great Britain.
Royal Irish Academy.
Royal Society of London.
Royal Society of Van Diemen's Land.

Sandberger, Dr. F.
Sandberger, Dr. G.
Sawkins, J. G., Esq., F.G.S.
Seckenberg Natural History Society.
Sharpe, Henry, Esq.
Sherwill, Capt. W. S., F.G.S.
Silliman, Prof., M.D., For.M.G.S.
Smithsonian Institution.
Society of Arts.
Sorby, H. C., Esq., F.G.S.
Spratt, Capt. T., F.G.S.
Statistical Society.
Stockholm Royal Academy of Sciences.
Suess, M. Edouard.
Symonds, Rev. W. S., F.G.S.

Taylor, R., Esq., F.G.S.
Tchihatchef, M. P. de.
Tegg, Messrs.
Threadwell, D., Esq.
Trapp, J., Esq.
Turin Royal Academy of Sciences.
Tyndall, J., Esq.

University College.

Vaud Society of Natural Sciences.
Verneuil, M. E., For.M.G.S.
Victoria Philosophical Society.
Vienna Geological Institute.
Vienna Imperial Academy of Sciences.

Wallace, A. R.
Warwickshire Natural History and Archæological Society.
Webster, T., Esq.
Wheatley, C. M., Esq.
Whitney, J. D., Esq.
Wiesbaden, Natural History Society of.
Williams, S., Esq.
Wood, S. V., Esq., F.G.S.
Wurtemberg Natural History Society.

Yates, James, Esq., F.G.S.

Zepharovich, Herr R. v.
Zoological Society.

List of PAPERS *read since the last Anniversary Meeting, February* 15*th*, 1856.

1856.

Feb. 20th.—Report of a Visit to the Dead Sea, by H. Poole, Esq.; forwarded by the Foreign Office.

——— On the Affinities of the large extinct Bird (*Gastornis parisiensis*), indicated by a fossil femur and tibia, discovered in the lowest Tertiary near Paris, by Prof. Owen, F.G.S.

——— On some Mammalian Fossils from the Red Crag of Suffolk, by Prof. Owen, F.G.S.

March 5th.—Notes on the Geology of some parts of South Africa, by R. N. Rubidge, Esq. (in a letter to Sir R. I. Murchison, F.G.S.).

——— On Fossil Remains in the Cambrian Rocks of the Longmynd, by J. W. Salter, Esq., F.G.S.

——— On the Lowest Sedimentary Rocks of the South of Scotland, by Prof. R. Harkness, F.G.S.

March 19th.—On some Organic Remains from the Bone Bed at the base of the Lias, by the Rev. Mr. Dennis; communicated by Sir Charles Lyell, F.G.S.

——— Note on the Borings in the Valenciennes Coal-field, by MM. Degousée and Laurent. In a Letter to A. Tylor, Esq.

——— On the Age of some of the Sandstones and Breccias in the South of Scotland, by Prof. R. Harkness, F.G.S.

April 9th.—On the Strata in the Cliffs of Hastings, by S. H. Beckles, Esq., F.G.S.

——— On the Geology of Sydney, Australia, by J. S. Wilson, Esq.; communicated by Sir R. I. Murchison, F.G.S.

——— on the Stratigraphical Relations of the so-called Sands of the Inferior Oolite, by T. Wright, M.D.; communicated by Prof. Ramsay, F.G.S.

——— On the probable Origin of the Dover Straits by means of a Fissure, by M. Ami Boué, For.M.G.S.

April 23rd.—On the Formation of Craters, and the Nature of the Liquidity of Lavas, by G. Poulett Scrope, Esq., M.P., F.G.S.

May 7th.—On the Lignites at Bovey-Tracey, by Dr. Croker; communicated by the President.

——— On some appearances observed in draining a Mere near Wretham Hall, Norfolk, by C. J. F. Bunbury, Esq., F.G.S.

——— On a Fossil Track from the Millstone-grit of Tintwistle, Cheshire, by E. W. Binney, Esq., F.G.S.

——— Analysis of the Cleveland Iron-Ore, by A. Dick, Esq.; communicated by Dr. Percy, F.G.S.

——— Notice of the Occurrence of Coal near the city of E-u in China, by the Rev. R. H. Cobbold. (From the Foreign Office.)

May 28th.—On the Silurian Rocks of Wigtonshire, by John Carrick Moore, Esq., F.G.S.

——— On the Influence of Ocean Currents on the Formation of Strata, by C. Babbage, Esq.; communicated by W. H. Fitton, M.D., F.G.S.

1856.

June 4th.—On the Keuper Sandstone and its Fossils at Leicester, by J. C. Plant, Esq.; communicated by J. W. Salter, Esq., F.G.S.

———— On the Keuper of Warwick and its Fossils, by the Rev. P. B. Brodie, F.G.S.

———— On a New Genus of Fossil Cephalopoda, *Diploceras*, by J. W. Salter, Esq., F.G.S.

———— on a New *Orthoceras* from China, by S. P. Woodward, Esq., F.G.S.

———— On Trap-dykes penetrating the Syenite in the Malverns, by the Rev. W. Symonds, F.G.S.

———— On the Oscillation of Land in the South Sea, by J. G. Sawkins, Esq., F.G.S.

———— On the Formation of Gold Veins, by L. L. B. Ibbetson, Esq., F.G.S.

June 18th.—On a Section of Mount Lacha near Mont Blanc, by Major Charters, F.G.S.

———— On the late Eruption of Mauna Loa, by W. Miller, Esq. (From the Foreign Office.)

———— On the Geology of Varna and its Vicinity, by Capt. T. Spratt, F.G.S.

———— On the Geology of Trinidad, by H. G. Bowen, Esq., F.G.S.

———— On the Chalk and Greensand Fossils of Aberdeenshire, by J. W. Salter, Esq., F.G.S.

———— On the Correlation of the Middle Eocene Tertiaries of England, France, and Belgium, by Joseph Prestwich, Esq., Treas. G.S.

November 5th.—On the *Stereognathus Ooliticus*, from the Stonesfield Slate of Oxfordshire, by Prof. Owen, F.G.S.

November 19th.—On the Occurrence of Crystallization in Stucco, by Dr. Buist; communicated by Sir R. I. Murchison, F.G.S.

———— On the Occurrence of Allophane at Charlton, by Prof. J. Morris, F.G.S.

———— On the Red Sandstone and Quartzite of the North-West of Scotland, by Professor James Nicol, F.G.S.

December 3rd.—On the Eruption of Mauna Loa in 1855–56, by F. A. Weld, Esq.; communicated by Sir C. Lyell, F.G.S.

———— On the late Eruption of Mauna Loa, by Mr. Consul Miller. (From the Foreign Office.)

———— On the Eruptions of Mauna Loa during the last sixteen years, by the Rev. Mr. Coan. (From the Foreign Office.)

———— On the Occurrence of an Earthquake at Rhodes, by Mr. Consul Campbell. (From the Foreign Office.)

———— Additional observations on the Geology of Bulgaria, by Captain T. A. B. Spratt, F.G.S.

December 17th.—On the Tertiary Freshwater Deposits of the Western Portion of the Grecian Archipelago, by Captain T. A. B. Spratt, F.G.S.

———— On an Ice-carried Boulder at Borgholm, by John Wolley, Esq.; communicated by Sir Charles Lyell, V.P.G.S.

1856.

December 17th.—On the Occurrence of Volcanic Bombs in Van Diemen's Land, by the Rev. W. B. Clarke, F.G.S.

——————— Analyses of Waters from the Turko-Persian Frontier, by Dr. Richardson and E. Browell, Esq.; communicated by W. K. Loftus, Esq., F.G.S.

——————— On some Minerals from Siam, by Messrs. Hillier and Moyle. (From the Foreign Office.)

1857.

January 7th.—On the *Dichodon cuspidatus*, by Prof. Owen, F.G.S.

——————— On a Fossil Ophidian from Salonika, by Prof. Owen, F.G.S.

——————— On some additional Cambrian Fossils from the Longmynd, by J. W. Salter, Esq., F.G.S.

——————— On some new Silurian Species of *Acidaspis* from Ayrshire, by Prof. Wyville Thomson; communicated by Sir R. I. Murchison, F.G.S.

——————— On two species of *Acidaspis* from Shropshire, by J. W. Salter, Esq., F.G.S.

January 21st.—On a Fossiliferous Ironsand occurring on the North Downs in Kent, by Joseph Prestwich, Esq., Treas. G.S.

——————— On some Crustacean and other remains from the Permian Rocks of Durham, by J. W. Kirkby, Esq.; communicated by Thomas Davidson, Esq., F.G.S.

February 4th.—On the Formation of Rock-basins, by J. Cleghorn, Esq.; communicated by Sir R. I. Murchison, F.G.S.

——————— On the Copper-mines of Namaqualand, South Africa, by Dr. Rubidge; communicated by Sir R. I. Murchison, F.G.S.

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

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

It was afterwards resolved,—

1. That the thanks of the Society be given to Sir P. G. Egerton, Bart., M.P., and Sir Charles Lyell, retiring from the Office of Vice-President.

2. That the thanks of the Society be given to S. P. Pratt, Esq., retiring from the Office of Foreign Secretary.

3. That the thanks of the Society be given to Prof. Thomas Bell, Colonel Sir P. T. Cautley, Sir P. G. Egerton, Bart., M.P., Prof. John Morris, Prof. John Phillips, and H. C. Sorby, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

Colonel Portlock, R.E., F.R.S.

VICE-PRESIDENTS.

R. A. Godwin-Austen, Esq., B.A., F.R.S.
William Hopkins, Esq., M.A., F.R.S.
Leonard Horner, Esq., F.R.S.L. & E.
Sir R. I. Murchison, G.C.St.S., F.R.S. & L.S.

SECRETARIES.

Robert W. Mylne, Esq.
Warington W. Smyth, Esq., M.A.

FOREIGN SECRETARY.

William John Hamilton, Esq., F.R.S.

TREASURER.

Joseph Prestwich, Esq., F.R.S.

COUNCIL.

Samuel H. Beckles, Esq.
Prof. Charles Daubeny, M.D., F.R.S. and L.S.
Earl of Ducie, F.R.S.
Hugh Falconer, M.D., F.R.S.
Thomas F. Gibson, Esq.
R. A. Godwin-Austen, Esq., B.A., F.R.S.
William John Hamilton, Esq., F.R.S.
William Hopkins, Esq., M.A., F.R.S.
Leonard Horner, Esq., F.R.S.L. and E.
Colonel Henry James, R.E., F.R.S.
Sir Charles Lyell, F.R.S. and L.S.
Prof. N. S. Maskelyne, M.A.
John C. Moore, Esq., M.A., F.R.S.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Robert W. Mylne, Esq.
Prof. R. Owen, M.D., LL.D., F.R.S. and L.S.
S. R. Pattison, Esq.
Col. Portlock, R.E., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
Prof. A. C. Ramsay, F.R.S.
Warington W. Smyth, Esq., M.A.
Alfred Tylor, Esq., F.L.S.

Trust Accounts.

Receipts.	£	s.	d.	Payments.	£	s.	d.
Balance at Banker's, 1st of January 1856, on the Wollaston Donation Fund	30	9	9	Award to M. Deshayes	30	4	9
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	30	7	0	Cost of Engraving Wollaston Medal, awarded to Sir W. E. Logan		5	0
				Balance at Banker's (Wollaston Fund)	30	7	0
	£60	16	9		£60	16	9

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

ALFRED TYLOR, S. R. PATTISON, } *Auditors.*

Feb. 9, 1857.

Valuation *of the Society's Property; 31st December,* 1856.

Property.	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. XII.				68	12	6
Due for Subscriptions to Journal				57	12	6
Due for Authors' Corrections in Journal				9	16	6
Balance in Banker's hands				124	14	0
Balance in Clerk's hands				8	17	8
Funded Property, 4578*l.* 19*s.* 2*d.* Consols, at 90				4121	2	0
Exchequer Bonds				199	15	3
Arrears of Admission Fees (considered good)	54	12	0			
Arrears of Ann. Contributions (considered good)	56	14	0			
				111	6	0
				£4701	16	5

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

Debts.	£	s.	d.	£	s.	d.
Due to Messrs. Taylor & Co.:						
On Journal, Vol. XII.	99	13	6			
,, Transactions, Vol. VII. Pt. 4	44	17	6			
,, Library Supplementary Catalogue	57	7	6			
,, Scientific Expenses	2	18	0			
,, Miscellaneous Printing	3	15	0			
				208	11	6
Balance in favour of the Society				4493	4	11
				£4701	16	5

Feb. 9, 1857. JOSEPH PRESTWICH, *Treas.*

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1856	117	16	0			
Balance in Clerk's hands	1	11	0			
Exchequer Bonds, invested out of Income 1854	199	15	3			
				319	2	
Composition received				31	10	0
Arrears of Admission Fees	12	12	0			
Arrears of Annual Contributions	12	12	0			
				25	4	0
Admission Fees of 1856				222	12	0
Annual Contributions of 1856				584	6	6
Dividends on 3 per cent. Consols				128	4	4
Dividends on Exchequer Bonds.....................				6	10	8
Publications:						
Longman & Co. for Sale of Journal in 1855 .	57	7	6			
Sale of Transactions	22	6	9			
Sale of Proceedings	1	13	11			
Sale of Journal, Vol. I. to VI.	14	8	6			
Sale of Journal, Vol. VII.	4	1	0			
Sale of Journal, Vol. VIII........................	4	17	6			
Sale of Journal, Vol. IX.	7	8	6			
Sale of Journal, Vol. X.	12	5	6			
Sale of Journal, Vol. XI.	50	15	0			
Sale of Journal, Vol. XII.*	124	17	6			
				300	1	8
Sale of Library Catalogue				1	12	6
Sale of Geological Map of England (Greenough)				7	10	0
				£1626	13	11

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

Feb. 9, 1857.

ALFRED TYLOR,
S. R. PATTISON, } *Auditors.*

* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XII.. £68 12 6

Due from Fellows for Subscriptions 57 12 6

Due from Authors for Corrections 9 16 6

£136 1 6

Year ending December 31st, 1856.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	51	17	8			
Fire Insurance	3	0	0			
House Repairs	19	14	9			
Furniture Repairs	9	7	10			
New Furniture	13	15	2			
Fuel	41	12	0			
Light	32	16	2			
Miscellaneous House Expenses, including Postages	53	9	8			
Stationery	19	0	5			
Miscellaneous Printing*	22	12	0			
Tea for Meetings	23	5	6			
				290	11	2
Salaries and Wages:						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Assistant in Library and Museum	6	0	0			
Porter	90	0	0			
House Maid	33	4	0			
Occasional Attendants	11	17	6			
Collector	22	11	0			
				483	12	6
Library*				93	10	10
Museum				20	14	9
Diagrams at Meetings				12	11	6
Miscellaneous Scientific Expenses*				6	2	1
Publications:						
Transactions	0	14	0			
Transactions, Vol. VII. Pt. 4*	56	11	0			
Proceedings	0	10	0			
Journal, Vols. I. to VI.	1	3	10			
Journal, Vol. VIII		7	6			
Journal, Vol. IX.	0	14	0			
Journal, Vol. X.	0	11	6			
Journal, Vol. XI.	8	2	8			
Journal, Vol. XII.*	308	4	8			
Journal, Vol. XIII	9	5	0			
				386	4	2
Balance at Banker's, Dec. 31, 1856	124	14	0			
Balance in Clerk's hands	8	17	8			
Exchequer Bonds, invested as above	199	15	3			
				333	6	11
				£1626	13	11

* Due to Messrs. Taylor & Co., in addition to the above, on Journal, Vol. XII. ... £99 13 6

	£	s.	d.
On Journal, Vol. XII.	99	13	6
On Transactions, Vol. VII. Pt. 4	44	17	6
,, Library (Supplementary Catalogue)	57	7	6
,, Scientific Expenses	2	18	0
,, Miscellaneous Printing	3	15	0
	£208	11	6

ESTIMATES *for the Year* 1857.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal	57	12	6			
Due for Authors' Corrections	9	16	6			
				67	9	0
Arrears (See Valuation-sheet)				111	6	0
Ordinary Income for 1857 estimated:						
Annual Contributions (185 Fellows)				582	15	0
Admission Fees				180	0	0
Compositions				63	0	0
Dividends on 3 per Cent. Consols				128	4	4
Dividends on Exchequer Bonds				6	10	8
Sale of Transactions, Proceedings, Geological Map, Library Catalogues				55	0	0
Sale of Quarterly Journal	225	0	0			
Due by Messrs. Longman and Co. in June, for sale of Journal in 1856	68	12	6			
				293	12	6
Balance against the Society				43	18	0
				£1531	15	6

[*N.B. This does not include* £199 15*s.* 3*d. invested in Exchequer Bills in May* 1854. *Considering which as available for this year's Income, the Balance in favour of the Society would amount to* £155 17*s.* 3*d.*]

JOSEPH PRESTWICH, TREAS.

Feb. 9, 1857.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	50	0	0			
Fire Insurance	3	0	0			
House Repairs	20	0	0			
Furniture Repairs	12	0	0			
New Furniture	15	0	0			
Fuel	30	0	0			
Light	35	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	20	0	0			
Miscellaneous Printing*	25	0	0			
Tea for Meetings	25	0	0			
				285	0	0
Salaries and Wages:						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Assistant in Library and Museum	30	0	0			
Porter	90	0	0			
House Maid	33	4	0			
Occasional Attendants	12	0	0			
Collector	23	0	0			
				508	4	0
Library, New Books, &c.*	35	0	0			
Museum	15	0	0			
Diagrams at Meetings	15	0	0			
Miscellaneous Scientific Expenses*	5	0	0			
Publications: Quarterly Journal*	450	0	0			
„ Transactions, &c.*	10	0	0			
				530	0	0
* Due to Messrs. Taylor & Co., in addition to the above (see Balance Sheet)				208	11	6
				£1531	15	6

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

25TH FEBRUARY, 1857.

Award of the Wollaston Medal and Donation Fund.

The President having been inadvertently detained, Sir C. Lyell, as Vice-President, was requested to take the Chair, and, the preliminary business having been concluded, he placed in the hands of Sir R. I. Murchison the Wollaston Medal, awarded to M. Barrande, saying:—

Sir Roderick Murchison,—I am called upon very unexpectedly, in the absence of our President, to explain to the Meeting the grounds on which the Council have awarded the Wollaston Medal of this year to M. Barrande, and to request you to take charge of the same and to transmit it to its owner. I might well have hesitated to undertake this task, to do full justice to which would be no easy matter, had I not had the good fortune in the course of the last summer to visit the neighbourhood of Prague, and to explore, in company with M. Barrande, the field of his successful labours. In this way I had an opportunity of learning by what means this eminent palæontologist had been able, after more than twenty years of persevering research, to accumulate single-handed so wonderful a collection of organic remains. I saw several of the large quarries, which he had opened at his own cost for the express purpose of collecting fossils, and heard him converse in their native Bohemian with the workmen whom he has taught to be his skilful fellow-labourers. I believe I am under the mark if I estimate at 1500 the number of new species of Invertebrata which M. Barrande has added to palæontology; and it is a singular fact that all the Bohemian fossils found by him in palæozoic strata older than the Devonian have proved, with the exception of a few brachiopods, to belong to species unknown elsewhere. When I beheld the quantity and beautiful preservation of the fossil stores heaped up in his Museum at Prague, they appeared to be more like the results of a Government Survey than the acquisitions of a private individual, and I felt convinced that no amount of zeal or pecuniary resources could have achieved this object had not the collector possessed also a profound knowledge of many distinct branches of natural history. M. Barrande's investigations have for ever set at rest one question once so keenly controverted, namely, whether there existed in Palæozoic as in Neozoic times distinct natural-history provinces of Mollusca and of other classes of Invertebrata. He has shown, not only in regard to the fauna called by him Primordial, but also in respect to his second and third faunas, corresponding with what we have usually termed Lower and Upper Silurian, that distinct assemblages of species inhabited simultaneously different marine areas. The Palæozoic species, for example, of Bohemia differed from those of Scandinavia, and the North American species from both. After examining, with M. Barrande as my guide, the beautiful sections of Silurian rocks laid open on the banks of the Moldau, I felt convinced that he had correctly interpreted the order and succession of the rocks, and in whatever manner we may endeavour to account for the intercalation in the midst of the Lower Silurian strata of certain distinct groups of species called by M. Barrande "colonies," we must at least accept the facts as true, and believe the exact position of the fossiliferous formations to be as they are described by this accurate observer.

I will now conclude by begging you, Sir Roderick, to present this medal to M. Barrande in the name of the Geological Society, and to assure him of the unmixed feelings of regard and admiration with which we watch the progress of his original and important labours.

Sir Roderick Murchison thus replied:—

Sir,—I have great satisfaction in being made the medium to convey to my eminent friend M. Barrande the Medal which has been bestowed upon him in terms so well suited to his merits.

It has been, I assure you, an increasing and constant source of delight to myself, who first explored the environs of Prague in the year 1829, when a few trilobites only were known in those 'transition' rocks, to mark from year to year the intelligence, zeal, perspicuity, and untiring diligence with which this distinguished French gentleman has rendered his 'Silurian Basin of Prague' truly classical, by amassing a multitude of organic forms hitherto unknown, by the philosophical spirit in which he has compared and illustrated them, and by the talent he has evinced in clearly defining their geological position and relations.

Knowing that M. Barrande went to Bohemia as a stranger who had to learn a difficult language before he could thoroughly inquire into the natural history of the country, and seeing that with very moderate means he has accomplished such grand results, I am certain that our Society never decreed an honour more thoroughly in the spirit of the illustrious Wollaston than at this Anniversary.

I am charged, Sir, by M. Barrande, to offer to the Geological Society the expression of his profound gratitude for what he terms "the highest distinction which a geologist can receive, since it emanates from those authorities who are the most respected and the most independent."

"I feel (he adds) that England, in thus bestowing marks of her consideration upon the working men of the Continent, powerfully contributes to maintain and excite the true zeal for scientific researches."

The President, Col. Portlock, having taken the Chair, proceeded to deliver the Balance of the proceeds of the Wollaston Donation Fund to Mr. S. P. Woodward, addressing him in the following words:—

Mr. Woodward,—As the Council has once before presented you with the proceeds, and as on that occasion your claims for such a distinction were fully explained, it is not necessary that I should now dwell at any great length on your general merits; but as the supplement to your 'Manual of the Mollusca,' which was the work to which the Council more particularly directed its attention on the former occasion, has been, since its first award, published, I cannot but refer to it, as having fully maintained the high character of the first two parts, and more than that, having brought before the student certain elements in the study of natural history which are frequently overlooked in the discussions of speculative geology. The comparison, for example, between the numbers of recent and fossil species is full of interest, and the result obtained—namely, that the number of species of shell-bearing Mollusca which are known to have appeared on the earth and passed away, is to the number of species now living nearly as 9 to 10—cannot be learnt without exciting in the mind very interesting speculation. The geographical distribution of the Mollusca is also a most interesting and valuable addition to the work; and when we look at the completeness which you have thus given to the work, at the expense of much deep research and most arduous labour, we cannot but admire the modesty which has given it to the world under the simple appellation of a Rudimentary Treatise. Nor is it amongst ourselves alone that the merits of your work have been acknowledged, as it has already become a work of reference in the hands of Foreign naturalists, including that well-known palæontologist, Bronn. In deciding upon this award, the Council had also in their consideration the work you have undertaken on the Radiata; and whilst acknowledging the great value of your 'Manual of the Mollusca,' have been anxious to assist you in the preparation of this new work, which they fully anticipate will in your hands be equally successful. Let me also, Mr. Woodward, whilst placing the proceeds in your hands, and thus fulfilling my duty as President, be allowed to express my personal feelings of respect and regard for one whose progress in science I have watched with interest for many years, and whose ability, industry, and genuine modesty I have ever appreciated and admired.

In reply,—Mr. Woodward expressed himself much honoured by the assistance and encouragement given him by the President and Council of the Geological Society. He was anxious to devote himself to the preparation of a Manual of the Radiated Animals, as they were much studied by geologists; while the only special work on the subject was the 'Manuel d'Actinologie' of M. De Blainville, published thirty-two years ago, and so little known in this country, that the copy in the British Museum remained *uncut* till he had occasion to refer to it. An elementary work was now wanted for the use of students, and its adoption would be much facilitated if it obtained the sanction of the Geological Society.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—It is now my duty, whilst delivering that annual address which you require from your President, to recall to your recollection those Members of our Society who, removed by death from amongst us during the past year, are deserving of especial notice, as having by their mental labour advanced the great cause of intellectual progress and acquired a high position in the estimation of men of science. In attempting to perform this painful task to my own satisfaction, I feel that I am obliged to review the history of our science for the last fifty years, as the first name on the melancholy list of illustrious men who have passed away from the halls of science is that of one of a band of intellectual giants who early in the present century seemed formed especially for the great work of laying the foundations of a new science; whilst the second is that of our late President, who was, as it were, the personification of a new school of men of vigorous minds, who, taking their stand on the foundation laid by their predecessors, are fitted, by their accurate knowledge and by their penetrating and liberal spirit, to complete the structure by enlarging its basis and filling up its details. By the death of Dr. Buckland, that early school of eminent men has been again reduced in number; but happy must we all feel that several of its most able members are still amongst us; men—it is unnecessary to mention names—who exhibit in the most striking manner a transition character, by uniting the excellences of both schools; and who, by possessing a freshness of thought and a boldness of conception which seem to defy the hand of Time, still maintain their ancient and undisputed post of leaders of our Society.

In attempting to detail the works of such men I cannot free myself from anxiety, as I fear some will condemn me for not passing over unnoticed their defects in judgment, and exhibiting them as men who have never mistaken the path of error for that of truth; but surely it is more profitable to look even at the greatest men as too often erring mortals, and, by tracing their mental changes, to draw a wholesome caution against the hasty condemnation of the opinions of others or the too prejudiced maintenance of our own. The greatest merit is not to be ascribed to men who have never altered their opinions under the light and influence of more matured knowledge; but rather to those who have frankly acknowledged their original errors and assiduously endeavoured to advocate the truth, however opposed it may have been to their first opinions; and in this light no man deserves our respect and admiration more than Dr. Buckland.

William Buckland was the eldest son of the Rev. Charles Buckland, Rector of Templeton and Trusham, in the county of Devon; he was born at Axminster, March 12th, 1784, and in 1797 was at the ancient grammar-school founded by Blundel, a cloth manufacturer at Tiverton*, in the 17th century; in 1798 he entered St. Mary's College, Winchester, and in 1801 Corpus Christi College, Oxford, as a Scholar on the Exeter Foundation. In 1805 he took his degree of B.A., and in 1808 was elected a Fellow of his College. At this time the lectures of Dr. Kidd, Professor of Mineralogy, began to draw attention to the study of geology, then first assuming in England the aspect of a regular science through the labours of the Founders of the Geological Society; and it was only natural that one who as a boy had manifested a strong bias towards the study of natural history, having commenced when at Winchester a collection of chalk fossils, should have eagerly listened to his teaching, and continued at Oxford amongst the shells of the Oolite his habit of collecting. His associate in such researches was Mr. Broderip of Oriel College, who had acquired much knowledge of these subjects from the Rev. J. Townsend, the friend and fellow-labourer of William Smith; and it is said that the fruits of the first geological walk up Shotover Hill formed the nucleus of that large collection which forty years afterwards Dr. Buckland placed in the Oxford Museum. From 1808 to 1812 he traversed on horseback a large part of the southwest districts, collecting from those tracts, which had been the scene of the earlier labours of Smith, materials for forming sections of the strata and grouping together their organic remains. In 1813 he was appointed Professor of Mineralogy at Oxford, on the resignation of Dr. Kidd, and became a Fellow of the Geological Society.

Ranking now amongst the most eminent inquirers into the physical history of the earth, he embraced, as Dr. Kidd had done, geology as well as mineralogy in his lectures, and quickly awakened in the University that admiration for, and interest in geology, which doubtless led to its public recognition as a science by the endowment, in 1819, of a Readership for Geology, a stipend having been allotted from the Treasury, at the instigation of His Royal Highness the Prince Regent, for the delivery of an annual course of lectures on Geology; and to this new office Dr. Buckland was appointed. The Inaugural Address which, on this occasion, Dr. Buckland delivered, on the 15th May, 1819, before the University deserves especial notice, as it expressed not only his own views upon questions then warmly discussed, but those of a large portion of men of science, including the great Cuvier. It was only natural that the discoveries then beginning to be made in geology should have alarmed some pious but rather narrow-minded persons who thought that they were at variance with the Mosaic account of the creation; but the objections they urged were met in a frank and manly spirit by Dr. Buckland, who quoted in support of his own opinions the following passage from the 'Records of Creation' by Sumner:—"According to the Mosaic history we are bound to admit, that only one general destruction or revolution of the globe

* The second centenary was celebrated on the day I joined this school.—J.E.P.

has taken place since the period of that creation which Moses records, and of which Adam and Eve were the first inhabitants. The certainty of an event of that kind would appear from the discoveries of geologers, even if it were not declared by the sacred historian. But we are not called upon to deny the possible existence of previous worlds, from the wreck of which our globe was organized, and the ruins of which are now furnishing matter to our curiosity. The belief of their existence is indeed consistent with rational probability, and somewhat confirmed by the discoveries of astronomy, as to the plurality of worlds." The evidence of geology has in fact proved the past occurrence of many convulsions, and there was therefore nothing, *à priori*, unreasonable in assuming that one of those convulsions might have been coeval with the Mosaic Deluge: the error, which, although it had been repudiated by Linnæus, was the error of the age rather than of the man, is that of supposing it necessary to vindicate geology by proving that this same deluge had been the cause of all the disturbances and denudations observed; and not ascribing them more correctly to the convulsion itself, or at least to that variation in the conditions of the earth's surface which at the same time led to the destruction of many species of animals now extinct as well as of many individuals of species still existing.

But though Dr. Buckland, with a candour never exceeded, abandoned at once his early and cherished opinions as regards the geological proof of the Deluge, when further examination and new discoveries had convinced him of their fallacy, we may still quote with admiration this Inaugural Lecture, published as it was under the title of 'Vindiciæ Geologiæ,' for most ably and nobly did Dr. Buckland defend geology and every other branch of science from the narrow views of utilitarians, who would at once do away with the real difference between Man and Beasts by confining the exercise of that intellect which assimilates Man to the Deity to the mere gratification of sensual wants, for which purpose the inferior endowment of Instinct is found sufficient in the ordinary animal creation. "Now," Dr. Buckland observes, "if by utility is meant subserviency to the common purposes of life (though it may be easily shown that geology had shrunk from a comparison with few other sciences even in this respect), yet such views should be altogether objected to *in limine* as unworthy and unphilosophical. The claims of geology may be made to rest on a much higher basis. The utility of science is founded upon other and nobler views than those of mere pecuniary profit and tangible advantage. The human mind has an appetite for truth of every kind, physical as well as moral; and the real utility of science is to afford gratification to this appetite. The real question then, more especially in this place, ought surely to be, how far the objects of geology are of sufficient interest and importance to be worthy of this large and rational species of curiosity, and how far its investigations are calculated to call into action the higher powers of the mind." Dr. Buckland then proceeded to dwell on those wonderful phenomena, organic and physical, which are the objects of a geologist's study, and adds, "surely these will be admitted to be objects of sufficient magnitude and grandeur to create an adequate interest to engage us in their investigation." Unquestionably; and, when we see, as is so often the case now, assemblages of simple but intelligent men listening with marked attention to Lectures on Geology, and on science generally, can we doubt that they afford useful mental food even to the most humble, and have a tendency to raise their minds from mere sensual indulgence to the healthy contemplation of natural and therefore divine truths?

In 1818 Dr. Buckland was elected a Fellow of the Royal Society; in 1824 he was chosen President of our Society; and in 1825, whilst still holding with memorable ability that office, he was advanced to a Canonry of Christ Church, having previously resigned his Fellowship and been presented to the living of Stoke Charity, Hampshire: soon after he married Miss Moreland of Sheepstead House, Abingdon, —an estimable lady, who shared and appreciated his scientific toil whilst she lightened the anxieties of life and spread a charm over home occupations by her devoted affection. In 1832 he was President of the British Association at its first Meeting in Oxford. He became a Fellow of the Linnean Society in 1821. In 1847 he was appointed a Trustee of the British Museum, the geological and palæontological collections of which he had actively promoted for several years, as he had also supported the establishment of the Museum of Practical Geology. In 1845 he was appointed, on the recommendation of Sir Robert Peel, Dean of Westminster; and, although it has been said that he never aimed at high distinction in theology, it cannot be doubted that his labours in advancing every branch of human knowledge which came under the scrutiny of his active mind were not without abundant success in producing that frame of mind which is best fitted for the contemplation and appreciation of divine wisdom. My last personal meeting with Dr. Buckland was on returning from the Meeting of the Association at Swansea in 1848, when I joined him, Mr. Greenough, and Mr. Strickland on the way to Cardiff, passed the evening with them there, and on the next morning crossed over to Bristol. My two other distinguished friends, who have also been removed from us, went on immediately to London, but Dr. Buckland remained with me to examine the Cathedral and the celebrated Red Church, and no time can efface the recollection of the enjoyment I experienced in being guided through those venerable buildings by one who freely and unostentatiously communicated the rich stores of his archæological knowledge. I parted with him at Didcot, he proceeding to Westminster and I to Oxford.

To form a correct notion of the powerful manner in which Dr. Buckland influenced the progress of Geological Science, it would be necessary, not only to pass in review the long series of his Geological Contributions, but also to realize the effect he produced on his hearers, and on the University generally by his lectures. In the present instance I must confine myself to the first of these objects, as I cannot hope to convey to the mind of any one, who had never heard Dr. Buckland speak, the inimitable effect of that union of the most playful fancy with the most profound reflections, which so eminently characterized his scientific oratory. In 1813 he visited the north of Ireland, in company with the Rev. W. D. Conybeare (now Dean of Llandaff), and the result of that most interesting vacation tour was published in the Transactions of our Society, 1816. It must be remembered that the discussions between Neptunists and Volcanists had not then ceased, and that in this most remarkable basaltic district the controversialists found ample materials for their respective arguments. The curious indurated porcellanic schist of Portrush, full of ammonites, having been confounded with true basalt, was eagerly cited as a proof, that basaltic rocks generally had been in a state of aqueous solution or suspension. Nothing could have been more sound than the analogy drawn by Dr. Richardson between the Portrush schist and other calcareous or argillaceous strata containing organic remains; his error was, in considering the Portrush rock "a fine basalt," and thus extending this analogy to the true columnar basalt of the adjacent district. Playfair pointed out the error of this reasoning, but it was still clung too, founded as it was, upon an important fact, which then remained isolated or without apparent connexion with the general phenomena of the district. The observations, however, of the Rev. W. D. Conybeare and of the Rev. W. Buckland strengthened the opinion of Playfair, by showing that these indurated strata were, by their organic contents, related to the strata of the adjacent country. About half-way between Ballycastle and Bushmills, near Ballintoy, the chalk formation rises sufficiently high to disclose its sub-strata: a valley opening towards the sea, near White Park, shows that they here consist of the slate-clay of the lias formation, with gryphites and ammonites. Farther west the chalk cliffs again emerge from the level of the sea, immediately beyond Dunluce Castle, and continue to rise till they are broken off at the commencement of the Portrush Strand. As they here exhibit nearly the same thickness which they possess near White Park, we are naturally led to expect the recurrence of similar sub-strata near this point, and accordingly in the peninsula of Portrush, a singular rock is seen divided by interposed masses of greenstone, but containing ammonites and gryphites, and possessing exactly that character which would be assumed by the slate-clay before described, if indurated by the action of heat. "The peninsula itself," they observe, "which may be about a mile in circumference, is fenced with low cliffs on the west, north, and east; those on the west present a rudely prismatic greenstone, those on the north and east tabular masses of greenstone, overlying, and in some places appearing to alternate with, a very remarkable rock, which has been the subject of much discussion among the supporters of opposite theories. It is a flinty slate, exactly similar to the indurated slate-clay which forms the wall of the Carrick Mawr dyke in the Ballycastle collieries; and the analogy is rendered the more striking from the further resemblance of the greenstone of that dyke to the greenstone of these cliffs. In this flinty slate are contained numerous impressions of *Cornua ammonis* invested with pyrites, the shells being similar to those found in the slate underlying the chalk near Ballintoy:" and "we felt convinced, while examining the spot, that the rock was no other than the slate-clay of the lias formation in an indurated state."

In 1814 Dr. Buckland visited, in conjunction with Mr. Greenough, an insulated group of rocks of slate and greenstone in Cumberland and Westmoreland, on the east side of Appleby, and his paper describing them was read March 28, 1815. Having pointed out the association of the slates with greenstones and the appearance in two localities of granite, enclosed as it were by the schists and differing from the Shap Fell granite, he enters on the consideration of the strata by which they are encircled. On the east side the Old Red Sandstone is interposed, with little disturbance, between the slates and the Mountain Limestone of Cross Fell; but on the west side, or in contiguity with the greenstone, there are evidences of considerable disturbance. The beds, so regular and of such great thickness on the east, appear but rarely on the west, whilst the red sandstone of the plain of Carlisle abuts, except in a few cases, abruptly against the greenstone and slates, or against the truncated extremities of the lower limestone strata. Without following the authors into minute details of the shattered limestones and associated coal-measures, some of which had been thrown into a vertical position and brought into contact with the greenstone, it may be observed that one great object was to prove the distinction between the more recent red sandstones of the plain of Carlisle, and the Old Red Sandstone or conglomerate that divides the great limestone series of Cross Fell from the slates, as the contact of both with the slate rocks had led to much confusion and many doubts upon the subject. The result of the investigation was, that Dr. Buckland came to the conclusion that the Carlisle red sandstone is the same with that of the vales of Cheshire, Salop, Lancashire, and York, the matrix of our quarries of gypsum and rock-salt, and is geologically a deposit more recent than the magnesian limestone which is incumbent on the upper strata of the principal English coal-fields. Such investigations as these were, at this early epoch, attended with great difficulties, and it cannot be said that they are even now always freed from such difficulties.

In 1816 was read the paper on the Plastic Clay near Reading, the result of inquiries made in 1814; and here we find him an able pioneer in the Eocene formations, sketching out as it were the leading features and beginning that system of correlation between the English beds and those of the Paris basin, which has since carried this section of geological research so very near to perfection. It is impossible to read this paper, in which we recognize the celebrated Woolwich beds, and the sands in contact with the chalk, and the wear and tear of the chalk, without admiring the acute and accurate observation he gave to a subject which has subsequently exercised so much patient inquiry.

Another paper, read March 15, 1816, described the curious siliceous bodies, like gigantic pears in form, found in the Chalk of the North of Ireland, and known under the name of Paramoudra. The animal nature of these bodies, and their analogy with other spongiferous bodies of the chalk, was maintained by Dr. Buckland, and the general theory of the separation or segregation of the siliceous matter from the compound pulp of lime and silex, of which the chalk deposit originally consisted, and of its assimilation by the organic tissues giving rise to those flinty bodies so common in the chalk, was fully and clearly explained.

December 3, 1819.—Attention had been directed by Dr. Kidd and Professor Playfair to the Lickey Hill in Worcestershire as the possible nearest source of the siliceous pebbles accumulated on the plains of Warwickshire and the Midland Counties, on the summit of some hills near Oxford, and in the valley of the Thames from Oxford to its termination below London, when Dr. Buckland, in whose mind the contemplation of the grand effects which may be produced by the action of water in some of its most striking forms had already obtained a powerful influence, proceeded to examine, in conjunction with Count Brenner of Vienna, the Lickey Hills. Subdividing them into two sections, the Upper and the Lower Lickey, he showed, that whilst the upper belongs to the overlying Red Sandstone, the lower Lickey, like the Stiper Stones, and the siliceous beds at the south-east base of May Hill, underlies, as Mr. Aikin had pointed out, what was then called the grauwacke slate, Dr. Buckland inferring that the true place of the quartz rock of the Lickey is "towards the lower extremity of that series of depositions which are usually associated under the name of grauwacke formations." It is curious to read these names of rocks in association with the *terra incognita* of the grauwacke formation, which have now been rendered so familiar to us in connexion with 'Siluria'; but though Dr. Buckland did not then anticipate the important geological position they would once hold, he afterwards pointed out how desirable it would be to give them a careful examination. The ready disintegration of the Lickey rock, in consequence of its brecciated structure, was pointed out; and Dr. Buckland, in the second part of his paper, considers the evidence which the transport of these pebbles over a wide range of area, as before noticed, bears to the fact of a recent deluge. It is unnecessary to follow the author in his reasonings upon this subject, or in his careful tracking, as it were, of the pebbles on their onward course, as no one can doubt the fact of such transport, though many may demur to the conclusions drawn from it. The same may be said in respect to the bones of the Mammoth, Rhinoceros, Hippopotamus, and other animals found in the so-called diluvial gravel; but even in this paper, where the object was to trace out the action of the deluge of Scripture history, Dr. Buckland was a true geologist, and already acknowledged the importance of the great principle of ordinary, as contrasted with extraordinary causes, by representing deluges as one class of ordinary causes; the Mosaic deluge being "the latest *diluvian* catastrophe that has affected the surface of our globe."

April 19, 1822.—In order not to break the continuity of Dr. Buckland's series of communications to the Society, I reserve the consideration of his able paper on the Alps, as well as of his 'Reliquiæ Diluvianæ,' and the paper which he read to the Royal Society in 1821 on the same subject, and which was crowned with the Copley Medal, until the close of my notice of his other works.

The paper read on April 19, 1822, upon the excavation of valleys by diluvial action, having been written before the publication of the 'Reliquiæ Diluvianæ,' may be considered a precursor of that remarkable work. Admitting, as every geologist must do, that the action of those internal forces which either elevate, depress, or crack the crust of the earth must in many cases tend to form, or at least to influence the direction of valleys, Dr. Buckland considered that the irregularities consequent on the preceding action of subterraneous forces had been modified by the action of violent *inundations* hollowing out portions of the surface and removing the fragments to a distance, at *different periods* of time intermediate between the deposition of the most ancient and the most recent formations. Here it is evident that Dr. Buckland assumed an action of inundations or floods, for the term cannot be applied to submarine currents, prior to the historic deluge; and in fact he connects them with that deluge by stating that "a cause similar to that last mentioned has wrought extensive changes on the surface (however variously modified by preceding catastrophes) at a period subsequent to the deposition and consolidation of the most recent of the regular strata. The diluvian waters to which these effects must be referred (if we except the very limited and partial action of modern causes, such as of torrents in cutting ravines of rivers, in forming deltas, of the sea in eroding its cliffs, and of volcanos in ejecting and accumulating mineral matter) appear to have been the last agents that have operated in any extensive degree to change the form of the earth's surface." Since that period the idea has become familiar to our minds, through the philosophical labours of Sir C. Lyell, that the forces and causes we see now in action, or in other words "the modern causes" of Dr. Buckland, are only so many exemplifications of the laws of Nature, —laws which we have no reason to believe have ever been other than invariable. Whilst then most modern geologists would assuredly ascribe the formation, as well as the modification of the many land valleys referred to by Dr. Buckland, to natural causes, such as are now in action, few would attribute them to the action of a violent and transient inundation; and if not the land valleys, how much less would they be disposed to admit that "the English Channel is a submarine valley, which owes its origin in a great measure to diluvian action"! It is unnecessary to enter here into a consideration of the great physical difficulty of placing water in such a position, or of investing it with such a moving power, as should enable it to produce by one great movement such magnificent effects; and I will only state my humble conviction, that the advocates of moderate forces continuing in action for a long time, rather than those who assume vast forces acting in a moment (as it were) of time, are at present in the ascendent.

1822.—About the same period Dr. Buckland was associated with the Rev. W. D. Conybeare in a paper (published in the same volume as the above) on the "South-western Coal District of England."

In this paper the rocks described are classified in the Wernerian order in two grand series: the first beginning with the transition rocks of old times, and ending with the coal formation; the second beginning with the newer red sandstone, and ending with the oolite, thus—

No. 1.

1. Greywacke.
2. Transition limestone.
3. Old red sandstone.
4. Carboniferous or mountain limestone.
5. Coal measures.

No. 2.

1. Newer red sandstone, comprising—
   a. Dolomitic conglomerate.
   b. Red sandstone.
   c. Red marl.
2. Lias.
3. Oolite.

The leading physical difference, namely want of conformability, between these two sections of rocks is pointed out by the authors; the first or lowest section being usually highly inclined, and the second or newer approaching more to horizontality; the authors deducing from this circumstance a caution for those who expect to find a coal deposit under every patch of new red sandstone, by pointing out that an envelope of this kind may spread over every or any member of the underlying inclined strata. The authors also explain that, though these two great series of deposits usually include, when complete, the members enumerated, it must not be expected that all should be found in every natural section, as one or other may be wanting, and thus a particular deposit may be brought into immediate connexion with another, from which, in a normal section, it would be separated by many others. In fact, the teaching of geology is, that when a mineral deposit has been linked to some definite epoch of the earth's history by the organic relics it contains, it ceases to be a mere crude mass of matter, and becomes a speaking page of that history. Other pages may be torn out or obliterated in the various copies of this history, but yet the still remaining pages will occupy their original and true position.

The principal basins of the district, which include as many important coal-fields, are thus classed:—

1. That of Somersetshire and South Gloucestershire as the basin of Bristol.

2. That of the Forest of Dean.

3. The great coal-basin of South Wales.

The boundaries of each of these coal-fields are traced, the distribution of the rocks described in the fullest detail, the phænomena of the faults investigated, and most remarkable they are, as, in the Bristol basin the limestone has been at one place thrown up to such an extent as to appear to re-emerge in the midst of the coal measures; whilst at another, the coal measures have subsided to such an extent as to appear to dip beneath the mountain limestone "on which they in fact repose." The paper is illustrated by numerous detailed tabular sections of the strata, in which the positions of the several seams of coal are exhibited, &c. so that the paper will always continue a valuable record of carefully observed facts and be consulted by the scientific miner as a useful guide.

There is also a brief notice of the fossils of the district; but this great subject had not as yet been fully developed or become a distinct science, nor had Siluria been explored, so that this part of the paper is not in importance equal to the rest. At the present moment, indeed, we can hardly estimate the true value of such elaborate papers, or the vast labour of collecting the data for compiling them; entering, as we now do, upon our inquiries, after these early pioneers of science have shaped out a course for us, and enabled us to pass easily over ground which to them was full of difficulties.

February 20, 1824.—In the paper read on this day, Dr. Buckland, then President of the Society, announced the discovery, at Stonesfield near Woodstock, of parts of the skeleton of an enormous fossil animal, which had been then deposited in the Museum of Oxford. This animal Dr. Buckland identified, though the fragments were few, as belonging to the order of Saurians or Lizards, and from the length of the largest thigh bone he deduced a length of 40 feet, and a bulk equal to that of an elephant; although, as he rightly observed, the same proportions cannot be always ascribed with safety to fossil and recent species. He named this animal, relics of which had also been obtained by Mr. Mantell from the Wealden, generically Megalosaurus, and it would appear that in his examinations he availed himself of the assistance of Mr. Conybeare and the great Cuvier. Dr. Buckland also noted the existence of the elytra of Beetles in the now so well-known deposit of Stonesfield, as well as the bones of what he then considered birds, but which he afterwards ascertained to belong to a Pterodactyle.

In this year Dr. Buckland contributed two other papers to the 'Transactions,' the first on the "Occurrence of Agates in Dolomitic Strata of the New Red Sandstone Formation in the village of Sandford, two miles east of Banwell." He describes them as exteriorly rugged, but internally as made up of alternating bands of chalcedony, jasper, and hornstone, disposed in irregular and concentric curves, the outermost being conformable to the irregularities of the external surface, whilst the interior is occupied by an amorphous mass of chalcedony and hornstone, through which are dispersed a number of smaller and nearly spherical agates. These agates resemble the Bird's-eye Agate, and are distinguished by Dr. Buckland from the imperfect agates called potatoe-stones, so common in these strata. Dr. Buckland ascribes the formation generally, but not always, to the infiltration of siliceous matter into geodes or cavities of the rocks, as in the case of the agates of trap-rocks; and he observes, that "wherever silex is present in a state of sufficiently minute division to be filtrated into any small cavity, there the formation of agates may proceed."

Dr. Daubeny is quoted by Dr. Buckland as having found entire beds of jasper and jasper-agate in the dolomite hills near Palermo; and in that region the formation of such bodies might be more readily assimilated to that of the geodes of trap-rocks; as it may be suggested that the infiltration of silica in an undissolved condition, however minutely subdivided, could scarcely lead to the formation of agates; and that it is more probable that the passage of highly heated steam through the rocks, under the influence of some kind of igneous action, has led to the solution of the silica, and its subsequent deposition in the cavities of rocks.

In the second paper, the discovery of the bones of an Iguanodon in the ironsand of the Wealden of the Isle of Wight and in the Isle of Purbeck is announced; its range being thus extended from Tilgate Forest, where it was first discovered by Dr. Mantell. These bones were accompanied by others of the Megalosaurus; and at Sandown Bay specimens of a Zamia, *Zamia crassa* of Lindley, were also found.

Such papers as these are most curious, as they show the careful but sure steps with which our early masters in this science tried their way, when walking in a hitherto almost unknown track and putting together, one by one, those links which were to be afterwards more completely combined into one whole.

February 7, 1825.—Dr. Buckland read a very interesting paper on the "Formation of the Valley of Kingsclere," and other valleys by the elevation of the strata that enclose them, and not by denudation. In this paper he explains the peculiar characteristics of such valleys in being surrounded by bold escarpments, the strata of which dip away from each other outwards. He then referred to the great valley of the Weald, and, applying his reasoning to it, he says that no force of water alone could have produced such effects as are here observed, though he was disposed to admit that such force might have been sufficient to remove the rubbish resulting from the previous disturbance, fracture, and elevation of the strata.

Following up the argument, he demonstrates that the Hampshire and London Tertiary Basins were probably separated from each other by the elevation of the subjacent chalk subsequent to the deposition of the strata of which they are formed, and points out as a confirmatory fact, that on the summits of some of the highest chalk hills between them are isolated masses of strata, of which the identity of character with that of the plastic-clay-formation in the basins of London and the New Forest affords abundant ground for concluding that these two basins were originally united together in one continued deposit across the intervening chalk of Salisbury Plain in Wilts, and the plains of Andover and Basingstoke in Hants; their separation into the two distinct basins of London and Hampshire having resulted partly from local elevations and depressions, by subterranean violence, since the deposition of the plastic clay; and partly from the still more recent removal of much of their substance by diluvial denudation.

A similar conclusion, bold as it must have then been considered, Dr. Buckland also drew from the position of insulated portions of tertiary strata, at elevations of 10,000 feet above the sea level in the Alps, as compared with that of the tertiary strata of the valleys of Italy, France, and Germany; so that here too he was the precursor of our most able living geologists.

April 18, 1828.—In this paper Dr. Buckland details the results of an examination, by himself and Mr. Clift, of a collection, made by Mr. J. Crawford, a Fellow of the Society, of organic remains found in a deposit on the east bank of the Irawadi, about half-way between Ava and Prome, between 20° and 21° N. lat. Up to this time the information respecting the geology of India had been very scanty, consisting principally of papers by Messrs. Colebrooke and Fraser in the first volume of the second series of the 'Transactions'; so that Dr. Buckland, in his 'Reliquiæ Diluvianæ,' had observed,—"Another interesting branch of inquiry is, whether any fossil remains of Elephant, Rhinoceros, Hippopotamus, and Hyæna exist *in the diluvium* of tropical climates; and if they do, whether they agree with the recent species of these genera, or with those extinct species whose remains are dispersed so largely over the temperate and frigid zones of the northern hemisphere;" a question which was answered, after the lapse of only five years, by the researches of Mr. Crawford, along the course of the Irawadi from its mouth near Rangoon up to Ava, a distance of nearly 500 miles. The collection consisted of both monocotyledonous and dicotyledonous plants, the former silicified, and the latter sometimes petrified by silex, and sometimes by carbonate of lime, and of fossil bones, in which the interest of the discovery principally depended. The bones were either fractured or worn by attrition, and were found in the sand and gravel, which Dr. Buckland still called diluvium and considered more recent than the alluvial formations of the great deltas. They consisted, in the Pachydermata, of two new species of *Mastodon* (*M. latidens* and *M. elephantoides*), one of *Hippopotamus*, smaller than the existing species, one species of *Sus*, one of *Rhinoceros*, approximating most nearly to the Rhinoceros of Java, and one of Tapir; in the Ruminantia, one species of Deer, and one of Antilope; in the Class Reptilia and Order Chelonia, of three species of *Trionyx*, very large, and one apparently an *Emys*; in the Sauria, of a species allied to, if not identical with, the great Gavial of the Ganges, and a Crocodile resembling *Crocodilus vulgaris*. Such an assemblage as this, connecting the ancient fauna of India both with the ancient and modern faunæ of America and Europe, and with the recent fauna of Africa, was well calculated to excite the admiration of one so enthusiastic as Dr. Buckland, and called forth from him the prophetic opinion, that, as he had anticipated in his first paper on the "Cave of Kirkdale," bones of Hyænas would be discovered in the diluvium of England, as they had been in that of the European Continent, so also on similar grounds he would argue, "that it is highly probable we shall hereafter find the Mastodon in our own diluvium and most recent tertiary strata,—a prophecy verified by the discovery of the Mastodon in our Crag. It is indeed in science alone that man may venture to prophesy, for it is there only he is acquainted with the laws, though sometimes only imperfectly, which link together the courses of natural events. The freshwater and marine tertiaries, also brought to light by these researches, as well as by those of Colebrooke, Babington, and Scott, were important extensions of those interesting deposits, which, first noticed in the Basins of London and Paris, had already become known in almost every state of Europe, as well as in Asia and Africa. The analogy of the Burmese tertiary fossils appeared to be with those of the London clay and Calcaire grossier, so that the Eocene Formation was even then beginning to assume an importance which is daily augmenting; as on the one hand it more and more presses on the miocene from below, whilst the pliocene in a similar manner encroaches upon the miocene from above. May 2nd, 1828.—It may be well to observe also, that Mr. J. B. Pentland enriched the fossil fauna of India by an Anthracotherium, or ruminant allied to *Moschus*, a very small Pachyderm, and a carnivore of the genus *Viverra*.

June 6, 1828.—In a paper read on this day, Dr. Buckland again became the expounder of the records collected by another labourer in the field, Mr. H. H. Henley, and described the Cycadeoideæ of the Oolite freestone quarries of the Island of Portland. Assisted by Dr. Brown and Mr. Loddiges, Dr. Buckland was enabled to establish a new family by the name of Cycadeoideæ, or "allied to Cycadeæ," as one of the extinct species resembled a recent *Zamia* and the other a recent *Cycas*. To these species he gave the names *Cycadeoidea megalophylla* and *C. microphylla*; and it is only further necessary to observe, that, as other observers had also discovered fossil plants of a similar character in other portions of the oolitic system, this section of the geological series of formations became impressed with a floral, as it has since been with an animal characteristic, which appears to assimilate it much more to the present organic condition of remote portions of the earth's surface than to that of the countries in which the fossils have been found.

January 16, 1829.—At this date Dr. Buckland read a paper on the "Secondary Formations between Nice and the Col de Tendi," which may be considered an appendix to the paper of Sir H. De la Beche on the same subject of the year before.

Later investigation has corrected some of the opinions stated in these papers, such, for instance, as the supposed occurrence of true Nummulites in association with fossils of the cretaceous system,—a statement subsequently repeated, as regards Brianza in Lombardy, where it was imagined that beds of nummulites had been discovered alternating with beds of Inoceramus-limestone: this view, however, has been shown to depend on an erroneous estimate of the stratification; the red marly limestone which alternates with the nummulitic conglomerate having no other relation with the cretaceous limestone of that locality than that of colour.

Sir H. De la Beche had expressed his belief that the gypsum deposit was common to several members of the geological series of formations, and in like manner that the dolomitic condition of a limestone afforded no test of geological age; opinions which, sound as they were in separating physical and chemical conditions from the consideration of the age of rocks, were accepted only with caution and considerable limitation by Dr. Buckland; so hard is it to discharge from our minds those ideal data upon which we have been accustomed to rely as the basis of our practical deductions.

February 6, 1829.—Dr. Buckland described and named the *Pte-*

rodactylus macronyx, discovered by Miss Mary Anning in the blue lias of Lyme Regis, and stated the occurrence of the elytra of coleopterous insects at Stonesfield, associated with the remains of Pterodactyles, of which such insects were probably the food. He expressed also his opinion that the remains of supposed birds at Tilgate Forest, were probably portions of Pterodactyles; adding a doubt "whether there be any certain evidence of the existence of fossil birds in strata more ancient than the tertiary." He appears to have shared these judicious opinions with the well-known and able palæontologist, Mr. J. S. Miller of Bristol.

February 6, 1829.—In another paper, read the same evening, Dr. Buckland describes the Coprolites or fossil fæces of Saurians, which he had discovered in the lias of Lyme Regis and in various other formations in such quantities that a stratum of "many miles in extent and many inches in thickness" was in one-fourth part of its substance composed of balls of coprolites. This discovery was the result of Dr. Buckland's previous identification of the album græcum as excrementitious matter of Hyænas in the Cave of Kirkdale; and glancing, as it were, over the long series of organic life and death, he concludes that, "in formations of all ages, from the first creation of vertebral animals to the comparatively recent period at which Hyænas accumulated album græcum in their antediluvian dens, the fæces of aquatic and terrestrial animals have been preserved; the coprolites being records of warfare waged by successive generations of inhabitants of our planet on one another, the imperishable phosphate of lime derived from their digested skeletons having become embalmed in the substance and foundations of the everlasting hills; the carnivora in each period of the world's history fulfilling their destined office,—to check excess in the progress of life and maintain the balance of creation." This was a great and bold generalization, worthy of a geologist whose aim it was to give a faithful record of the early history of our planet; and we may fairly say that so sublime a conclusion was never before drawn from materials of so humble, so obscure a nature.

April 2–16, 1830.—In this paper Dr. Buckland was associated with Sir H. De la Beche, and the object was to describe the Southern Coast of England, from the Promontory of White Nore, eight miles E.N.E. of the town of Weymouth, where Mr. Webster ended his sections, to Weymouth and Portland, and thence westward along the Chesil Bank to the cliffs west of Lyme Regis; as well as to illustrate the adjacent inland district, including all the strata which lie between the great south escarpment of the chalk downs and the sea; or, as Dr. Buckland called it, the Weymouth district. The geological importance of this tract is strongly dwelt upon, as it embraces the consideration of tertiary strata, chalk, greensand, Purbeck and Portland beds, several other members of the oolite formation, and the lias, and thus permits the comparison of the south-western boundary of these formations to be made with the north-eastern boundary on the coast of Yorkshire, as well as with that portion of them visible on the coast of Normandy, whilst it exhibits examples of the violent disturbances which have affected them, producing, as in the Wealds of Kent and Surrey, in Purbeck and in the Isle of Wight, elevations, fractures, depressions, and denudations. This paper exhibits all that clearness of description which might be expected in the work of two such men; but I shall not follow it through the details of the older formations, contenting myself with dwelling for a moment on the tertiary, as it is in this paper that the author points out, that between the western termination of the chalk basin of Hants and Dorset and the great S.W. escarpment of the chalk, there occur *insulated patches* of the same tertiary deposits which fill that basin; thereby showing that they once extended beyond their present outlines, and were probably almost coextensive with the chalk. These patches, or fragments of deposits which have been so nearly swept away by denuding forces, are sometimes beds of rounded chalk-flint pebbles, either alone or alternating with sand, brick-earth, and plastic clay; sometimes of large blocks of a siliceous pudding-stone, consisting of chalk-flints imbedded in highly indurated siliceous sand; and sometimes of deposits of angular gravel and unrolled flints with yellow clay and sand, varying in thickness from 2 to 20 feet, being level on the top but irregular below, as they fill up the deep holes (puits naturelles) and furrows which pervade the entire surface of the subjacent chalk.

Dr. Buckland ascribed the production of the latter beds to the dissolving action of comparatively tranquil water upon the chalk, by which the flints have been, as it were, let loose; and he further supposes that the actual deposition, or formation, of tertiary strata, including the clay with chalk-flints, closed up the chalk-pits or *sand-pipes*, and preserved them from obliteration by atmospheric agencies. Dr. Buckland points out the difficulty of distinguishing such tertiary deposits from simple detritus, drift, or diluvium; in consequence of which the breccia composed of red clay and imbedded angular chalk-flints of Normandy, which Dr. Buckland and Sir H. De la Beche considered allied to the plastic clay, had been confounded with diluvium. The importance of these remarks will become strikingly evident at a future stage of this address.

June 5, 1839.—A notice of an elephant's molar tooth found in the bed of the Bristol Channel near Watchett, and of another thrown up on the Chesil Bank, Dorsetshire: this notice was printed as an appendix to the paper of Captain J. B. Martin, Harbour Master at Ramsgate, in which he enumerates fragments of six Mammoths dredged up in the British Channel, and a molar tooth found in the red clay at Ramsgate,—those obtained by trawling having been found in depressions between chalk ridges at the bottom of the Dover channel, and parallel to the chalk cliffs of both sides.

In addition to this long list of papers embracing almost every subject of geological interest, Dr. Buckland appears to have intended to present to the Society a very extensive communication on the "Structure of the Alps and adjoining parts of the Continent, and their relation to the Secondary and Transition Rocks of England," of which he published a prospective notice in the Annals of Philosophy for 1821. In this paper, justly considered a most able one, Dr. Buckland pointed out the errors which were the natural result of the too ready and general use of the ancient term "transition." The identity of the crystalline axis of the Alpine chain with the so-called primitive rocks, whether massive or schistose, of other parts of the world, was accepted as a well-known fact; but from this point upwards Dr. Buckland's task was one of correction. Separating at once from the transition class, to which they had been by several writers on the Alps allotted, the salt and gypsum, the older Alpine limestone, and the red sandstones, conglomerates, and porphyry, he placed them in the new red sandstone system of England; the Alpine limestone being, in his opinion, the equivalent of the zechstein and magnesian limestone, whilst the younger Alpine limestone was divided into three sections, the lower corresponding with the Jura limestone, the middle with the greensand, and the upper with the chalk. Below these rocks Dr. Buckland admitted a true transition series, identical, as he says, with the then so-called greywacke slates of Cornwall, Wales, and Ireland; and, in fact, he placed the schists of Blattenburg in the Canton of Glarus, and of Matt in the same canton, in this section. It is true that subsequent research has carried the reform of the old views of Swiss geologists much further, and that much of the transition strata admitted as such by Buckland has been transferred to formations of a far more recent date; yet we must admit that his first steps towards this reform were bold, and that his classification of the several dolomitic strata, as well as of the successive formations of gypsum, in reference to their better-known analogies, was a valuable rectification of the views then entertained. In fact, the difficulties he had to contend with may be understood from his own statement, that the term "greywacke" had been applied to beds of the new red sandstone formation, as well as to true transition rocks; that of "transition limestone" to the Alpine limestone or magnesian limestone, as well as to true transition limestone; that of "transition gypsum" to the saliferous gypsum of the new red sandstone, as well as to that which accompanies true greywacke; "Pierre" and "gryphites" to lias, "Calcaire à gryphites" to magnesian limestone; "Jura limestone" to oolite, lias; and magnesian limestone; "nagelfluh" (the position of which in the tertiary formations was so well shown by Buckland) to agglutinated gravel, Riga pudding-stone, and new red sandstone conglomerate. That Dr. Buckland should not have entirely reduced this mass of confusion to order, can be no matter of surprise, more especially when we remember how many long-received opinions had to be abandoned before one should be found bold enough to suppose, as Murchison did, that crystalline schists might be metamorphosed strata even of the cretaceous epoch.

1823.—I have retained that remarkable work, the 'Reliquiæ Diluvianæ,' on which a large portion of the great reputation of Dr. Buckland was founded, that it might be considered by itself. In the Philosophical Transactions of 1822, Dr. Buckland had noticed the Cave of Kirkdale, and explained its relations to similar cases in England and Germany; but in that great work he enters more fully into the subject, and propounds, as the basis of his argument, that the remains of animals found in the caves afford the means of judging of the inhabitants and character of the surface of the earth before the great Flood recorded in the Mosaic history; and, further, that the form and structure of hills and valleys, and the accumulation of loam and gravel containing the remains of animals of the same kind with those that occur in the caverns, must be taken as so many results of the action of that great deluge, considered in the light of a "recent and transient inundation"—being the last great convulsion which has operated in modifying the form of the surface: the terms ante-diluvial, diluvial, and post-diluvial expressing, therefore, the views of Dr. Buckland on the animals of the caves, the loam and gravel deposits, and the alluvial deposits subsequent to them.

Those who remember the first publication of this work must remember also the enthusiasm it created in the minds of all classes of intelligent readers; the geologist being struck with admiration at the facts brought before him in so graphic a manner, whilst the theologian felt, as it were, relieved from any apprehension he might have entertained, by being thus assured that the earth itself gave out its testimony to the truth of the Mosaic Deluge. All were therefore in accordance respecting the value of the 'Reliquiæ Diluvianæ;' and, whilst searching the masses of earth impregnated with animal matter, the contents of these animal charnel-houses, or gazing at the vivid picture which Dr. Buckland had drawn of the hyænas and of the bears in their respective dens, or watching, as it were, the supposed diluvial wave cutting through the earth's surface, forming valleys, and sweeping away the materials to form beds of gravel and sand elsewhere, they overlooked the many flaws in the testimony which they were thus adopting as a corroborative proof of that great catastrophe. The great Cuvier had already distinguished the hyænas and the bears from the existing species, and Dr. Buckland was fully aware of such determination, as he recognizes and describes them as distinct species: and yet, whilst carefully separating those deposits of bones, &c. which from their contents he considered post-diluvial, he still continued to represent the extinct species as a portion of the inhabitants of the earth at the time of the Mosaic Flood, and therefore as contemporary with the still living species, or as a portion of the present organic world.

Whilst, however, dwelling on these apparent defects in the reasoning of this work, I cannot but state that in my own opinion the difficulty of accounting for the formation of valleys and for the distribution of detritus by a diluvial wave, is much greater than that of associating the extinct species described with the recent, as parts of our creation; for the one case requires the exhibition of physical forces in a manner not easily conceived, whilst the other only assumes that certain genera or species of animals inhabited at that remote period portions of the earth where they no longer exist, and that the extinct species were local and destroyed by the Deluge; for, even adopting the most literal interpretation of the Mosaic account, the preserving agency of man could not have extended to regions so remote from the then inhabited portion of the earth. I do not say this because I think it either essential or possible to connect the extinction of these animals once living in the caves of Europe with the Deluge; but because I feel, that from the first moment when living species began to appear amongst the debris of the earth's crust, we have entered on the history of the earth as it now stands, and that from the earliest dawn of the present organic creation to the present time, there have been, as stated so strongly by Dr. Buckland in his other papers, numerous catastrophes, not indeed diluvial as he represents them, but depending on the action of the forces which produced those fractures, upheavals, and subsidences of the earth's crust, which no one can now doubt to have occurred. By every one of these some portion of a fauna, as yet very partially distributed, may have been destroyed; and I cannot help thinking that when the tertiary strata shall have been fully and finally investigated, the geologist will be able to trace out the regions which have been inhabited by each animal species, and connect the disappearance of many with some one of those great catastrophes, including amongst them, as one at least of the most recent, the Mosaic Deluge.

1836, *Bridgewater Treatise.*—Thirteen years had elapsed since the publication of the 'Reliquiæ Diluvianæ,' when Dr. Buckland was called upon to write one of those remarkable works, in accordance with the will of the Earl of Bridgewater, which were intended to draw from every branch of science, moral, physical, and natural proofs of 'The Power, Wisdom, and Goodness of God as manifested in the Creation.' It is now unnecessary to dwell upon that portion of the work which endeavours to remove the scruples of those persons who desire to explain all natural phænomena in reference to the text of Scripture, as the error of confounding a moral with a physical revelation has already nearly expired, and even the most pious men now study nature only in the records which have been preserved of it either upon or in the earth's crust; but, leaving this ground no longer debateable amongst men of science, it may be fairly said that this work is a compendium of geological and palæontological science up to the date of its publication, enriched by many reflections of a highly philosophical character. The keen perception of Dillwyn, now also lost to us, in discovering that the fossil turbinate univalves of the earlier formations, up to the lias, belong to herbivorous genera, whilst carnivorous univalves are very rare below the chalk and very abundant above it, was put into contrast with the equally remarkable distribution in time of the Cephalopoda, which, by their predaceous and carnivorous qualities, were destined to check the too rapid advance of animal organic life, the period of their maximum in genera and species having been anterior to the tertiary epoch and of their minimum posterior to it. This view of the substitution sometimes of genera, and sometimes of classes, in the place which others had before held, for the production of similar effects in the economy of nature, is deserving of careful attention whenever the theory of successive creations is brought before us, as it affords a powerful test of the value of the conflicting opinions upon that subject.

The wonderful discoveries of Cuvier, the philosophy of Lyell, the anatomical skill of Owen, all became tributaries to Buckland in the formation of this work, and it would be vain to attempt here a perfect analysis of its rich stores of knowledge or a full exhibition of the ability of its author by applying them to the illustration of his subject; but I may point out the interesting manner in which he describes, as he had partially done before, the beautiful discovery by Miss Anning of the ink-bags of cephalopoda in the lias, and the able explanation of the manner in which the siphuncle of chambered cephalopods performs the supposed function of elevating or depressing the animal in its aqueous medium. The object of this mechanism had been guessed at, but the actual *modus operandi* had not been explained, when Dr. Buckland, basing his argument on the anatomical description of Owen, who had traced the siphuncle or pipe of the recent Nautilus from the small initial chamber up to a sac, near the heart of the animal, filled with a fluid, the coat of the sac and the non-elastic membrane of the siphuncle being both impervious to water, Dr. Buckland assumes that this pericardial fluid, by being forced into the siphuncle, then in a collapsed state and empty, adds to the weight of the shell and sinks the animal; or being withdrawn from the siphuncle, diminishes the weight of the shell, which then acts as a float and brings the animal to the surface*.

I here close my remarks on the labours of Dr. Buckland, and I now think it desirable to point out in the strongest light those high qualities which he possessed in no ordinary degree, namely, candour and freedom from prejudice. I have explained his views of diluvial action, embraced as they had been with all the natural fervour of his character; and yet, when Agassiz made his appearance amongst us as the propounder of a glacial theory, which was in his opinion to explain the phænomena of erratic matter of every description, no one welcomed him with more ardour or more zealously set to work to trace out the glaciers of Great Britain than Dr. Buckland: but I must stop; this leader amongst us has indeed passed away, but he has left abundant records of the high position he so long occupied amongst geologists, and of the great value of his unremitting labour. Dr. Buckland possessed great natural strength of body, which made him equal to any amount of exertion, and Sowerby has recorded the anecdote of his galloping off with a huge ammonite over his shoulders, his head passed through the opening occasioned by the loss of the central volutions, when his companions dubbed him on the spot an Ammon-Knight; his invariable cheerfulness and humour threw life

* Beautiful as this explanation is, it must be received with hesitation, so far as respects the rise or fall of the animal, as it must be remembered that the fluid, assumed to be incompressible, still remains, in either case, in the animal, and therefore neither adds to nor diminishes its absolute weight. By changing its position, it causes the shell to rise above or sink below the animal, but the actual depression or elevation of the animal depends on the increase or diminution of its specific gravity by the sudden retraction of the animal within the open terminal chamber of the shell, or by its sudden expansion beyond it, when the pericardial fluid enters the body and depresses it in position below the shell, which then rises with it to the surface.

and light over the discussion of any subject he took in hand; and, whether describing with his pen or with his tongue the ancient inhabitants of the earth, such was the vivid reality of the picture that he drew, that they appeared to act and almost speak before us; so that I may fairly designate him the Æsop of extinct animals. Alas! himself now extinct; how can we hope to see again in all its fulness a second Buckland?

The great philosopher, whose labours we have endeavoured however feebly to notice, lived to complete his task and enjoy all the honours which were so justly his due; but now we must turn to another, who, taking up the subject of geology at a more advanced stage of its history, was apparently destined to carry it much nearer towards ultimate perfection, when a fatal accident removed him from amongst us only a short time after the unanimous vote of the Geological Society had placed him at its head as President. The gloom which was thus suddenly cast over us will never be forgotten, as every one had anticipated a most glorious scientific career for Daniel Sharpe.

Daniel Sharpe was born in Nottingham Place, Marylebone, in 1806.

His mother was a sister of Samuel Rogers, the poet. He was the youngest of a large family, and his father and mother both died a few months after his birth. He and the rest of the family were taken charge of by an elder half-sister, who brought them up at Stoke Newington, thus illustrating the inestimable blessing which a good and wise sister is ever felt to be to a young bereaved family.

After being a couple of years at a school in Newington, he went, at the age of twelve, to the school of Mr. Cogan, in Walthamstow, where he obtained a good knowledge of the classics. At sixteen he left school and went into the counting-house of a Portuguese merchant in London. He remained as a clerk there till the age of twenty-four, when he removed for a year to Portugal, and on his return joined an elder brother, Henry, who was already established as a merchant in London.

As a boy he always exhibited a fondness for natural history, but did not pay any particular attention to geology, until he joined the Geological Society in 1827, being then about twenty-one years of age. His first active labour in geology was bringing up, in 1828, from Somersetshire, a slab of stone at which he worked for many months, at length revealing to view an Ichthyosaurus, a description of which he afterwards published.

In 1835 he went to Portugal on business, and remained there till 1838. While there he made the Geological Observations on the neighbourhood of Lisbon, which he read to the Society in 1839. He was afterwards frequently called by business to Portugal for a few months at a time, and each time brought back the results of further observations.

Besides natural history, he was also very fond of philological studies, and gave great attention to the discoveries of Major Rawlinson and others in the East. In the second account published by Sir Charles Fellows of his antiquarian discoveries in Asia Minor, will be found an appendix by Mr. D. Sharpe, on the Syrian language, as shown on the tombs at Xanthus.

He was actively engaged in business all his life, and a regular attendant every day at his counting-house. He was never married.

Such is the simple record of the life of a man who, amidst all the cares of business, found time to master the most abstruse difficulties of literature and science; nor did he neglect his social duties as a Christian philosopher, as for many years, and till his death in 1856, he was Secretary of a School in Harp Alley, Fleet Market, for the education of the poor, an object in which he took an interest scarcely secondary to that he felt for his favourite science, geology. Let me now endeavour to give some idea of the loss which geology experienced by the death of Daniel Sharpe, by passing in review his works done and his papers presented to our Society.

Of the papers read in 1832, 1839, and 1840, the second enlarges and corrects the first, and describes the geological structure of the neighbourhood of Lisbon. The upper portion of the deposits described forms a rather remarkable tertiary deposit of considerable extent, extending from the mouth of the Tagus, 80 miles in length, from Lisbon, and 50 miles in breadth, only a small portion of this basin being to the north of the Tagus. The tertiaries are divided into three sections: the Upper Tertiary sand without fossils, consisting of 100 feet of fine quartzose sand and 150 of coarse quartzose ferruginous sand and gravel. It is remarkable for exhibiting, near St. Ubes, a rock consisting of irregular perpendicular tubes, from ½″ to 1 foot in diameter, formed of a very ferruginous sandstone, connected together by horizontal layers of the same substance, the cement being phosphate of iron. The centres of the tubes and the spaces between them are filled with ochreous sand passing into the ordinary sand of the country. This curious phænomenon is seen only in a very limited space, namely 20 feet in height and depth, but how far it might be traced inland cannot be determined. Quicksilver has been found in this deposit as well as gold.

The middle or Almada beds, consisting of alternating sands, clays, and limestones, contain fossils, and are about 350 feet thick. Of 43 species identified by Mr. Sowerby, 10 were recent, 10 Bordeaux species, 3 Paris basin, 3 London clay, 2 Crag fossils, 1 London clay and Bordeaux, 4 Subapennine; or of the shells corresponding to those of well-recognized localities, 26 were from the higher sections, and only 6 from the decidedly lower sections of the tertiaries, one of which was neutral, being common to the London clay and Bordeaux.

The Lower Tertiaries consist of a conglomerate without fossils, about 200 feet thick.

The Secondary formations consist of a limestone, sometimes soft and argillaceous, sometimes in the form of a beautiful hard marble containing fossils belonging to the family *Rudistes*, and nearly related to the genera *Hippurites* and *Sphærulites*, about 300 feet thick: a red or ferruginous sandstone, containing lignite and various impressions of leaves and stalks too imperfect for description, as well as seed-vessels; some portions being calcareous with a few fossils of rather a heterogeneous character: the Espichel limestone, of considerable thickness, and containing also a few fossils like those of the sandstone, of rather a mixed character: then slate-clay associated with trap-rocks; a dark-grey limestone, being crystalline in the vicinity of granite, and containing casts of 1 univalve and 1 bivalve shell, too much crushed for determination; and then another red conglomerate without fossils.

The Hippurite limestone, the Red sandstone, and the Espichel limestone Mr. Sharpe had at first associated with three different formations—the Cretaceous, the Oolitic, and the Liasic; but he subsequently altered this opinion, and placed them all in the cretaceous epoch, without attempting to allocate them to their several divisions, though in all probability the Hippurite limestone belongs to the Chalk and the other two to the Greensand. The still lower formations he did not coordinate with the recognized geological formations of England, the data being insufficient.

The Igneous rocks are also described with great care and discrimination; they consist of erupted or basaltic rocks and massive or granitic rocks. The basalt appears to have been erupted at two epochs: the newer, which is found capping some of the hills and is occasionally covered by tertiary deposits, was erupted subsequent to the cretaceous epoch, as it appears to have elevated, disturbed, and flown over its strata; the older is associated with deposits more ancient than the chalk. The granite forms a small ridge of hills seven miles long, four broad, and elevated 2000 feet at its highest point. The position and form of this diminutive alpine ridge are such, that its effects on the strata can be readily estimated, and by careful observation Mr. Sharpe determined that the elevation or protrusion took place between the deposition of the lower and the middle member of the cretaceous system. Small portions of syenitic and porphyritic rocks are connected with the granite: but we shall merely further remark that many interesting observations were made on the faults and other disturbances of the strata; and that, in an appendix on the great earthquake of 1795, the curious fact is stated, that the shock operated on the tertiary strata only, the line of quiescence being the boundary between the secondary and tertiary rocks.

This paper, interesting to us as the first detailed paper of our late respected President, is not only valuable for its geological merit, but also as it affords a striking illustration of the candour of its author, who, considering truth the first great characteristic of a true geologist, did not hesitate twice to correct the opinions he had previously expressed, and by so doing practically inculcated on the young geologist the wholesome precept, that he who climbs a pinnacle before him must expect to discover from its summit many mistaken turns in the path he has passed through, and be enabled thereby to correct his future progress.

Feb. 2, 1842.—In describing the works of Dr. Buckland I might have pointed out that, when he wrote his 'Bridgewater Treatise,' Lyell had already concentrated a flood of light on the Tertiary strata, but that the transition strata still remained in obscurity, no one having as yet dispelled the darkness which for so long a time had hung over them. Mr. Sharpe was in a different position; and in the present paper, which describes the geology of the south of Westmoreland, the investigation was lighted up by a torch which had already been kindled by Sedgwick and Murchison. Taking as his clue the labours of Sedgwick on the Coniston Limestone, and making that rock the basis of his observations, he established a series of five members, viz.—

1. Coniston Limestone.
2. Blue Flagstone.
3. Windermere Rocks.
4. Ludlow Rocks.
5. Old Red Sandstone.

Of fifteen species of Silurian fossils in the Coniston limestone, seven belonged to the Lower Silurian rocks of Murchison, and Mr. Sharpe therefore placed it on a parallel with that division, as Mr. Marshall had, on the authority of Sowerby, placed it on a parallel with the Caradoc. The blue flagstone succeeds in conformable order to the Coniston limestone, but contains no fossils; the faults which have affected one affect also the other, and Mr. Sharpe considered the absence of the fossils to be due to a re-arrangement of the particles in consequence of a metamorphic action. 3. The Windermere rocks, 5000 feet thick, consist of three divisions,—argillaceous schists, schistose grits, and calcareous bands, or calcareous schists. The stratification is much intersected by cleavage planes; and the few fossils found by Mr. Marshall induced Mr. Sharpe to consider it probable that the lower division might be about level with the summit of the Lower Silurian system, or the base of the Upper. 4. The Ludlow rocks, consisting of hard argillaceous strata, are unconformable to the Windermere rocks, and contain thirty-four species of the Ludlow Testacea figured by Murchison. 5. The Ludlow rocks almost graduate into the Old Red, which, as in Herefordshire, admits of a triple division.

In respect to the ages of the disturbances, Mr. Sharpe considered the outburst of the Shap granite subsequent to the deposition of the Coniston limestone and Windermere rocks, but anterior to the deposition of the Old Red, the beds of which remain horizontal or undisturbed; and that the faults which affected the Old Red Sandstone, and which also appear to have affected the Ludlow rocks, were of course subsequent to the protrusion of the granite. All the minute and varied effects consequent on such disturbances were described by Mr. Sharpe, and this paper bears striking testimony to the great ability of its author: that portion of it, indeed, which seems to prove, at least by inference, that the disturbances which affected the lower members of the Westmoreland series were separated by a considerable interval from those which subsequently affected even the Old Red Sandstone, deserves especial attention in any discussion upon the unity of the Lower and Upper Silurians.

1842.—Following up his inquiries, Mr. Sharpe next proceeds to investigate the age of the Bala limestone. Here we enter on that debateable ground which has been the subject of dispute ever since. In the first days of the labours of Sedgwick and Murchison, Professor Sedgwick thought he recognized an Upper and a Lower Fossiliferous System, below the Lower Silurian of Murchison, and this view was at first adopted by Murchison. The Bala and Coniston limestones were thus at first considered contemporaneous formations, and placed together in the Upper Cambrian; but as Mr. Marshall had classed, by the evidence of fossils, the Coniston limestone with the Caradoc,—a view adopted by Mr. Greenough, Professor Sedgwick afterwards separated these limestones, retaining the Bala limestone in the Upper Cambrian, but abandoning the Coniston to the Lower Silurian. The object of Mr. Sharpe was to prove that the Bala and Coniston limestones both belong to the Silurian.

In 1843 he again went over this ground, and corrected some minor points connected with these papers.

March 6, 1844.—*Geology of North Wales.*—In this paper Mr. Sharpe proposed to himself to determine the very important question, whether any fossiliferous deposits exist below the Silurian formation. The Llangollen district was the first examined, and Mr. Sharpe concurred with the late Mr. Bowman in allotting its rocks partly to the Ludlow and partly to the Wenlock series, the micaceous and shaly beds of the Ludlow portion not being here separated into two parts by any representative of the Aymestry limestone, and the slates and shales of the Wenlock portion being rich in the characteristic genus *Creseis*, to which Mr. Sharpe added three new species. The Silurian rocks are, near Corwen, overlaid by an outlier of mountain-limestone. In one portion of the district the Upper Silurian rocks (the Ludlow with a mountain-limestone cap) rest conformably on the Lower Silurian, whilst in another the Wenlock beds rest unconformably on the Lower Silurian roofing-slate. This conformability is stated to be rare in North Wales; but in a district disturbed by faults, unconformability alone cannot be considered sufficient evidence for the separation of the Upper from the Lower Silurians.

Mr. Sharpe reviews his former section of the Bala beds; and, enumerating nine, he includes the upper seven, all of which, excepting the uppermost, are fossiliferous, in the Lower Silurian; but he allocates the two lowest, which are not fossiliferous, to the Cambrian; though the absence of fossils, on which the negative evidence for fixing the line of separation between the two formations depends, can rarely be considered sufficient.

The region north and south of the Dee is next examined, and a dark roofing-slate without fossils is again found to rest upon loose schists full of fossils, and including two beds of fossiliferous limestone. The fossils are those of the Lower Silurian, and the rocks themselves rest unconformably upon a poor roofing-slate, considered by Mr. Sharpe to be the upper portion of the Cambrian. There is a striking resemblance between the Bala and the South Dee series, modified occasionally by an irruption of felspathic rocks amongst the latter. The Cambrian slaty rocks without fossils form, as Mr. Sharpe states, an irregular saddle in the middle of the Berwyns; and the anticlinal axis of the South Dee Silurian and Cambrian rocks extends to Cader Berwyn, the summit of which is a partially columnar greenstone. Again, on the Holyhead road Lower Silurian schists are found, covered up by unconformable Wenlock strata. On the road from Caernarvon to Holyhead the same junction of the Wenlock and Lower Silurian is observed; but we shall not further follow this part of the subject, as Mr. Sharpe appears fully to have established the fact that all the fossiliferous beds are characterized by true Silurian fossils, according to the most generally recognized meaning of the term Lower Silurian. The descriptions of the igneous rocks and the explanation of the condition of the slates worked west of Snowdon, which are shown to be a repetition of the same bed produced by contortions consequent on the intrusion of greenstone, the determination of the various axes of disturbance, faults, &c., are all proofs of close and careful observation. Mr. Sharpe makes also some very judicious remarks on the differences observable between the Lower Silurian and Cambrian rocks of North Wales and those of the English Border Counties.

The comparative paucity of organic remains he considers to depend on the greater thickness of the beds, or on the greater sea-depth of the deposit, in conformity with the principle established by Edward Forbes,—that the number of species and of individuals decreases as the depth increases, but that the lateral range of species increases as the depth increases, so that in deep-sea deposits of the same age there should be fewer species and a greater similarity between them at different localities. The Wenlock series near Llangollen is 3500 feet thick,—a vast accumulation compared with that of the same series in Worcestershire; but in addition to this evidence of a deep-sea deposit, Mr. Sharpe adduces also the ordinary habitat of the genus *Creseis*, which in the Mediterranean abounds in the muddy bottom of the sea at great depths, and is only sparingly found in more shallow water; and I must consider the natural-history proof the best in such cases, as it is so difficult to determine what physical changes may have been taking place during the deposition of such vast masses.

Mr. Sharpe first entered on the subject of cleavage in this paper; and, following up the law established by Professor Sedgwick, that cleavage planes maintain their parallelism over extensive areas, irrespective of the varying position or the mineral character of the beds they cut through, he arrived at the further law, that the strike of the cleavage coincides with the prevailing or normal strike of the beds, and continues uniform, not varying with the local variations of the strike of the strata; thence concluding that cleavage cannot be the result of crystallization: and again, as the planes are arranged with such regularity, and are not affected by the variations in the strike of the strata, that they are *not* the effect of *mechanical force or pressure exerted* *at the moving or upheaving of the rocks.* He also states that in undisturbed or horizontal strata the cleavage- and bedding-planes meet at an angle from 15° to 30° ; and that the slates are bad when this angle is below 20°, and good when the angle rises above 25°. These deductions, however, have been merely made from observation, and not from any considerations connected with physical laws ; but this most interesting subject will again be referred to when considering his subsequent paper on the subject of cleavage, in which the actual relation between cleavage and pressure is established.

1848.—Resuming his researches in Portugal, and examining the district of Oporto, he was fortunate to discover slates containing several most distinctive Silurian fossils. The great difficulty in this case was, that a deposit of coal and carbonaceous shales and sandstones containing impressions of ferns, some of which closely resemble true coal-plants, appeared to separate the Silurian deposit from crystalline rocks, granite, mica schist, and gneiss ; a fact which led Mr. Sharpe to inquire whether it was possible that the same species of plants could have been repeated at such widely separated geological periods.

1850.—Mr. Sharpe once more entered on the subject of Portugal, and in a paper of great ability completes his labours upon this country. The Silurian rocks, noticed in the preceding paper, are again mentioned in connexion with the anthracitiferous shales ; the latter underlying the former. The Tertiary deposits, the Hippurite limestone, an equivalent of our Chalk, the Subcretaceous series, the Jurassic series and some sandstones of an undetermined age, are more fully described than in the preceding paper, and are now illustrated by numerous fossils. Of the Tertiaries, the Almada beds were, on the authority of Mr. Smith of Jordan Hill, classed with the miocene. In respect to the Hippurite limestone, Mr. Sharpe corrected a slight error of his former paper, in which he had confounded it with another limestone of an earlier date. The fossils exhibit a remarkable difference in comparison with those of the chalk of our own country, comprising no cephalopods nor brachiopods, while of thirty-seven species, twenty are entirely new, and seven are species first described by D'Orbigny ; so that the fossil resemblance is singularly small. The fossils of the subcretaceous rocks are considerable in number, though many of them also are new ; but the abundance of the *Gryphæa Columba* in the Figueras limestone seems to render the identification of its position satisfactory.

The determination of much of the jurassic series depends rather on its position under the subcretaceous than on its fossils, which are very rare ; but the evidence of a few Ammonites from the limestone near Coimbra induced Mr. Sharpe to place that limestone in the Jurassic system, without, however, attempting to determine its position, or that of other corresponding limestones, within the system.

Below these beds occur a series of beds of sandstones and limestones, rich in fossils of a jurassic or oolitic type, and underlaid by a coal deposit of the oolitic age, as it contains the same species of

Zamites as the oolitic coal of Yorkshire; and further below there are sandstones of an age not at present determinable. It is remarkable, as pointed out by Mr. Sharpe, that, in looking at the correlation of these beds with better-known deposits, the approximation decreases as the beds become more recent; as for example, in the cretaceous (or Hippurite) series 45 per cent. of the fossils are described species, in the subcretaceous 53 per cent., and in the jurassic 84 per cent.; and on this Mr. Sharpe observes, that, whilst the species common at each epoch to Portugal and Northern and Middle Europe afford evidence of diminishing facilities of intercommunication as time progressed, it would be rash from such a fact to build up an argument for the greater diffusion of species at earlier epochs without having previously studied the habits, and powers of migration, of the animals, the relics of which they are.

1854.—Mr. Sharpe read a paper on "The Structure of Mont Blanc," to which I shall have occasion to refer at a later period of my address. In it he dissents from the views of Professor James Forbes, as regards the superposition of the granite of the Alps upon secondary rocks.

1855.—In a paper read Dec. 5, Mr. Sharpe made a bold attempt to determine, by the supposed marks left by the sea on the sides of the Alps, the age of the last elevation of that mighty mountain-chain. Instead of explaining the erosion of the surface visible to a great height, as Agassiz had done, by the action of glaciers, Mr. Sharpe confines the action of glaciers to valleys, and assumes that ancient glaciers had never extended more than 3000 feet below the present limit of glaciers, thus rendering it necessary to seek for some other cause of erosion at levels above and below certain limits, and specially for that deep erosion which he considers incompatible with the action of moving ice at all. This erosion he ascribes to the action of the waves of the sea whilst washing the base of the rocks, and notes three several lines at which the sea must be supposed to have rested sufficiently long for the production of such an effect. The first of these is at the height of about 9000 feet; the second at about 7500 feet, which can be traced through a great part of the centre of Switzerland (and which Professor Forbes considered the upper limit of erosion), cutting through the nummulitic as well as the jurassic rocks; and the third line of erosion at 4800 feet. Mr. Sharpe further ascribes the later degradation of the Alps, the removal of large masses and the formation of Alpine valleys, to the same cause, namely, the wear of the sea, aided by the denuding force called into action by the sudden changes of level, previously mentioned; and then, coordinating with the levels of the lines of erosion the different elevations above the sea at which valleys terminated and terraces were formed, he obtained a similar result to that which he had already deduced from observing the lines of erosion alone: namely, that, after the Alps had attained their present form, and when they stood as much above the surrounding country as at present, they were once more nearly submerged below the sea, and then were raised again out of it by several steps or comparative starts, after each of which was a period of rest long enough to allow the waves to leave a permanent record of their action; and further, that throughout Switzerland the whole chain was equally elevated, or as nearly so as can be determined by this method of observation. The moves were supposed to commence by jumps of 1000 feet or more, but then to become less, and at last scarcely discernible; the periods of longest rest correspond to the lines of erosion at 9000, 7500, and 4800 feet, and the epochs are supposed to have extended from the termination of the eocene to a period subsequent to the last tertiary deposit, nothing but drift having been formed during the last period of elevation. The various valley-terraces Mr. Sharpe supposed to have been formed of detritus heaped up by the sea at the mouths of river openings, or ravines, at each temporary rest, and the correspondence of height of these terraces in different and widely separated valleys with the lines of erosion, he considered a strong proof that at least both were results of some common cause. But, even were this admitted, the preservation of such terraces would appear inconsistent with violent changes of level, as the sudden rise of the land and the drag of the receding waters must have at least disturbed their loose materials, and shattered their mass, so as to destroy that regularity which is now their great characteristic.

Grand as this speculation is, it requires to be tested by more extended observations. Portions of the secondary as well as of tertiary deposits stretch into the Alpine valleys, so that it is evident that either the present configuration of much of the surface must have existed prior to the most ancient of these deposits, or that the rocky nucleus must have been forced through them subsequently, so as to produce by local disturbances the valleys as they now exist; the latter being probably most consistent with the disturbed character of much of the strata,—such, for example, as the anthracitic jurassic beds, which are found resting horizontally on the tops of the Aiguilles Rouges and at the same time in the valley of Chamounix below.

This indeed is Mr. Sharpe's view, as he states, that at the end of the Eocene period, the elder Nagelfluh, the enormous thickness of which is seen at the Rigi and neighbouring mountains, points out the period of that great elevation, when the central masses of the Alps being thrust upwards for the last time through the crust of the earth, the mountains received their present form, and the secondary rocks on the flanks were thrown into the disturbed position they now occupy, whilst the alternation of freshwater and marine deposits in the Molasse indicates pulsations, as it were, in the earth's crust, sometimes producing elevation and sometimes depression; but then, in his opinion, the whole country sank again at least 9000 feet, and at a later period a new and final elevation commenced, the consequence of which was fresh wear, and the dispersion of gravel and boulders over the low lands of Switzerland. On such an hypothesis, some of the later tertiaries, the fauna of which so nearly resembles that of the existing epoch, become separated from it in time, by the vast period assumed as necessary, first, for the subsidence of the whole country through a space of 9000 feet, and then for its elevation to the same level. Surely such a break in the continuity of a fauna so nearly identical in its parts, should of itself induce us to pause before we accept this theory, however ably constructed; and further, can we imagine that this vast interval, during which the whole of Switzerland was depressed more than 9000 feet, and then again uplifted at successive intervals, should have left no traces of intermediate formations other than ordinary drift? Nor can we avoid observing, that the general configuration of the land, including the valley of Geneva and its Lake, having been produced before the supposed final depression and elevation of the Alps, the sea-action during any one of the steps of rise would be insufficient to explain the passage of boulders, or their deposits, at high levels on the Jura, without the intervention of ice, which it is the object of the paper to dispense with. The sudden elevation of a large mass of land or water would doubtless produce a great wave, proceeding in all directions from the centre of the disturbed mass outwards, as the water would at first be partially carried up with it, and then roll back, acquiring velocity in proportion to its height; but, as that velocity would be very small at first, the action would be small also, and no uniformly polished surface could be produced; and, as regards the portion of water not participating in the motion, little effect could be produced; as, for example, while the mass was raised 1500 feet, or the space between the lines of 9000 feet and 7500 feet, the Molasse of the Swiss basin must have been covered by 6000 feet of water, and therefore have been secured from any dynamical disturbance consequent on the addition of water to its surface; the results of the overflowing water being made manifest in regions far distant from the limits of the basin rather than on its own bottom. On the actual line of a sea-level the effect could have been little more than that of loosening materials, which would then roll down into the waters below, following the wave, and not preceding it, just as is the case with the stones and gravel on the sea-shore as they roll down after the receding tidal wave; and it is difficult to conceive that any sufficient velocity could be bestowed upon a rocky mass by such a process as to have transported it to any great distance, surely not more than it would have acquired by moving freely through space for the same vertical distance.

Such problems are of surpassing difficulty, and assuredly require long and patient study for their solution; nor should it be forgotten that the action of the sea is by no means so powerful in producing effects such as are here supposed. Very friable strata are certainly much worn; but on the rocky shores of the Mediterranean the line of water-level is rather shown by growth of seaweed than by erosion; where, however, the water is aided by littoral tidal action, and bears along with it sand and gravel, erosion is sometimes very striking; though the ordinary wear by wave-action is very irregular, some portions of less cohesion giving way before others, and the general result being the formation first of caverns and then of bays, the harder portions remaining as projecting capes or promontories. Around a small island this action would be more continuous and less varied, but even then the wave-action would modify the outline of the groove produced; and, as regards the wearing of the valleys, it scarcely seems possible that any regular and continuous excavation could be produced by a succession of starts, each 1000 feet in extent, with intervening intervals of rest *.

Mr. Sharpe's palæontological papers are of considerable interest and value. For a genus of Gasteropodous shells abundant in Portugal he proposed (1849) the name *Tylostoma*, considering it distinct from *Globiconcha*, *Natica*, and *Phasianella*. The genus *Nerinæa* he enriched with six new species; dividing it into four subgenera—*Nerinæa* 65 species, *Nerinella* 10, *Trochalia* 6, *Ptygmatis* 12, besides eight species which he thinks ought to be placed in other genera; so that this genus of fossil Gasteropods is alone supposed to exhibit at least 93 species;—one of the many examples of the extraordinary multiplication of species in those early ages,—so great indeed as to force upon the mind of every one the necessity of caution and vigilance in attempting to establish new species at periods when it is very possible the range of variation may have been greater than it now is, whilst the characteristic of colour, and often that of either external or internal markings, are lost. Twelve species were found in Portugal, six of which had been previously described as cretaceous species; so that Mr. Sharpe concluded that the *Nerinææ* in Portugal or the South of Europe are cretaceous fossils, whilst in the North they are oolitic.

Sir Charles Lyell having submitted to Mr. Sharpe for examination the fossils he had collected in North America, the result was a very able analytical paper (1848) on the Mollusca of the collection, being so far an estimate of the labours of the United States Geologists. Referring to Mr. Hall's table, in which five subdivisions are enumerated below the equivalent of the Llandeilo flags, Mr. Sharpe disputes this last position, and asserts that there are no grounds for believing that any of the beds are of an earlier age than the Lingula beds of North Wales. At the same time Mr. Sharpe admits that no species found in any bed below the Trenton limestone, the upper of the five beds in question, are identical with those of England, though in the Trenton rock many such Lower Silurian fossils have been found; but he considers that the presence of Lingulæ, though not of the same species, in the Potsdam sandstone, the lowest American fossiliferous deposit, may well justify the assumption of its being equivalent to the Lingula-flags of North Wales. The great subdivision of the strata in Hall's table is considered a source of difficulty, and doubtless the separation of several limestones from each other, when so nearly parallel, must lead to great misconception, the supposed equi-

* Our lamented friend often observed, in respect to this paper, "What will the Swiss geologists say?" One Swiss geologist, M. De la Harpe, has answered this appeal by an able criticism of the paper, in which he not only endeavours to show that the evidence is insufficient to determine the permanency of level of the lines of erosion, or the synchronism of those lines with the terraces of Alpine valleys, but also adduces much of the argument I have myself advanced in the above remarks.

valents of the Wenlock series being here split into twelve members. Some curious results are deduced from this investigation; as, for example, whilst the Gasteropods of America and Great Britain are apparently totally distinct, and few species of the Lamellibranchiate bivalves are common to both countries, above two-fifths of the Brachiopoda are common to both,—a fact which, as Mr. Sharpe suggests, may be due to the limitation of littoral shells in their expansion in space by the necessity of a continuous shore, whilst deep-sea genera and species may admit of a much wider distribution. Ingenious and natural, however, as such explanations appear, they depend on so many peculiarities in the condition of the earth's crust in the spaces which separate distant countries, as to become merely speculative; but one remark of Mr. Sharpe requires especial notice, as being a proof—and he gave many—of that philosophic spirit which so strongly characterized him:—"It would be interesting," he says, "to trace out the first appearance of each species in many countries, and to see whether it is found in one at an earlier period than in another country, and thus learn of what region it was originally native;"—an inquiry, which, were it possible to trace out also the extent of variation to which species may have been subject from gradual alteration of place and circumstances, would assuredly be one of the most interesting the geological naturalist could follow out.

Every member of this Society is aware of the zeal and industry with which Mr. Sharpe applied himself to the investigation of fossils, whether collected by himself and to be used in illustrating his own papers, or collected by others and merely submitted to him for examination in aid of labours not his own. In conjunction with Messrs. Bunbury, Salter, and Rupert Jones, he described the fossils collected by Senhor Carlos Ribiero from the Carboniferous and Silurian rocks of Portugal. In this paper one new genus of corals, *Disteichia*, and two new species were described from the Silurian, as well as 24 species of Testacea, some belonging to new genera recently established by M. Rouault. The Trilobites identified by Mr. Salter had all been previously recognized as Silurian fossils, and are seven in number, sufficient to verify the geological classification, but still not enough to prevent our wishing for something like that patient form of comparison with which Mr. Prestwich has made us familiar under the term *correlation*. Of other Entomostraca Mr. Jones described a species of *Beyrichia*, *B. Bussacensis* (Jones), closely allied to *B. complicata* (Salter), and another, *B. simplex* (Jones), closely allied to and forming a passage between *B. Logani* and *B. strangulata*.

Of 14 plants, Mr. Bunbury considers all which could be identified as belonging to the true coal formation, with the exception of one, a *Walchia*, which might be either Coal or Permian; 4 of the 14 occur in the anthracitic formation of the Alps, and 6 have been recorded as British. The general resemblance is to the coal of France, and the absence of *Lepidodendron*, *Calamites*, and *Sigillaria* is noted as a remarkable peculiarity.

Passing by some minor papers, one of which however, on the sand and gravels of Farringdon, is highly interesting, and all of which have their peculiar value, I must pause for a moment to record the labour and the scrupulous precision with which Mr. Sharpe fulfilled the task, which he had undertaken for the Palæontographical Society, of describing the Mollusca of the Chalk of England. Part 3 of this description, containing a portion of the Cephalopoda, has been published since his lamented death, and has just been placed in my hands. It contains the description of 25 Ammonites, 11 Turrilites, and 8 species of the curious body called Aptychus, which Mr. Sharpe endeavours with great ability to allocate to their respective species of Ammonites. Of the Ammonites described in this Part, 15 are common to our own chalk and that of the Continent, and 10 are as yet only known as belonging to the British chalk. Of the Turrilites 7 are common to our chalk and that of the Continent, and 4 are known as yet only in our chalk; or, in other words, 60 per cent. of the Ammonites are general and 40 per cent. local; and of the Turrilites, 64 general and 34 local: proportions which, so far as our present knowledge goes, mark a difference between the faunæ of two comparatively near natural-history-regions which is worthy of much consideration, more especially when it is considered that the difference would be more striking were the Continental species which have not been found in our chalk taken into account, and also that the Cephalopoda cannot be supposed to have been so restricted in their powers of locomotion as other Mollusca.

1854.—I shall now refer to the paper on the structure of the Alps. In this paper Mr. Sharpe abandons the fan-shaped foliation of the gneiss of Mont Blanc, and states his discovery of two distinct vertical lines of foliation, nearly parallel, and separated by a narrow, steep, anticlinal axis; and in the same manner he recognizes a similar axis and vertical foliation in the parallel chain of the Aiguilles Rouges. Without entering into more minute description, it may be observed that Mr. Sharpe's object is to prove that when the gneiss or metamorphic rocks appear to rest upon the secondary strata which occur in patches in this region, it is only an illusion, the supposed planes of bedding of the gneiss being only planes of foliation; and that, though the secondary strata appear to dip under planes of bedding, they merely abut against the sides of the gneiss, the apparent conformability being simply a conformability in the planes of foliation. Had Mr. Sharpe rested here, his opinion would have merely stood in opposition to those of others in respect to the interpretation of the effects of cleavage in these rocks; but he goes further, and questions the accuracy of other observers, especially objecting to Professor Forbes's statement, that the limestone dips under the granite in the Valley of Chamounix, as well as to that of M. Favre, who so distinctly asserts that the schists appear to dip under the granite and *rest upon* the secondary beds.

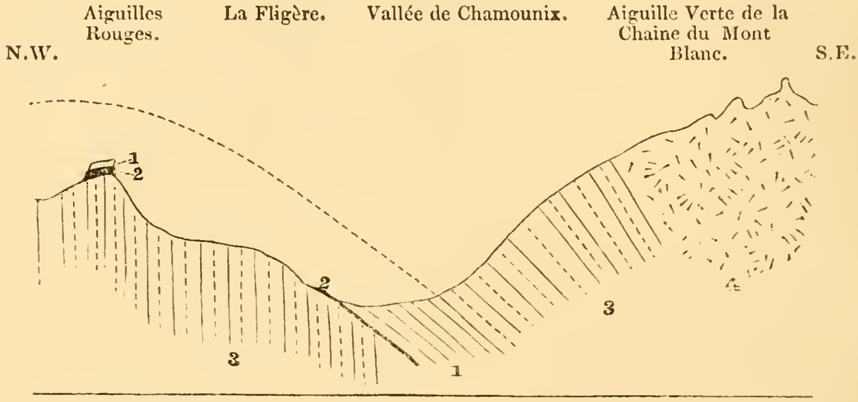
From the days of Saussure the Alps have been a problem submitted to geologists for solution, and which still continues only partially solved. It is in the Alps that the association of anthracitic beds containing coal-plants with semi-crystalline schists on the one hand, and their association on the other with beds, containing Ammonites and Belemnites of supposed jurassic age have called forth the ingenuity of the most able foreign and English geologists in their endeavours to explain a conjunction which appears to be in opposition to the received principles of the science. To the discussion of this difficult question no less than sixty-eight memoirs have been devoted, including the Addresses of Lyell and of Hamilton, and the papers of Murchison; and the recent discussion of them by M. Albert Gaudry has fully exhibited the varieties of opinion and reduced them to something like order. Some, for example, have considered the alternation of the anthracitic and liassic beds as the result merely of a folding of the strata, the result of physical disturbance; others have considered the zoological characteristic of less value than the botanical, and therefore placed all the beds in the Carboniferous series; others again have viewed the zoological of more importance than the botanical, and allotted the whole to the Jurassic;—in one case, therefore, assuming that the Belemnites and Ammonites may have commenced their existence in the Coal-period, and in the other, that the Carboniferous plants may have extended theirs into the Jurassic; whilst M. Fournet suggests that below the true Jurassic beds there may have been a Triassic zone, or, as it were, a neutral ground between the two formations.

This brief notice of a discussion, which even now has not arrived at a definite result, is sufficient to show how obscure a region which has been the scene of so many great physical disturbances must necessarily be, and to prepare us to expect many difficulties in the consideration of its stratification. For a long time indeed it had been admitted by most observers, that the secondary rocks of the Alps were in many places overlaid by the crystalline schists which formed the sides of the great central granitic axis; and some therefore boldly recognized in such schists metamorphic rocks of the carboniferous epoch, and other rocks of the cretaceous epoch, according to the view respectively taken of the geological position of the secondary rocks. Mr. Sharpe, however, viewing the rocks of the Alps under a different aspect, consequent on the application of his theory of cleavage, denied that the planes which separated the mass of the crystalline rocks into apparent beds were anything more than planes of cleavage, and consequently that the superposition was not like that of strata deposited one over the other, or a superposition of bedding, but simply apparent; and in so far as this, Mr. Sharpe only exercised a legitimate right in applying his own theory towards the exemplification of facts; but he was not equally justified when he maintained that other authors had been deceived as to the facts themselves, and asserted that M. Favre had nowhere seen the crystalline schists of Mont Blanc lying upon the sedimentary beds in the manner represented in the section which accompanied his paper.

This subject was brought forward again during the Session by Major S. Charters, in a paper on a section of Mont Lacha, near Mont Blanc, where he states the dip of the strata to be to the north, at an angle of 75°, the planes of the cleavage being perpendicular to those of bedding, and therefore dipping at an angle of 19° towards Mont Blanc, under which, if mistaken for bedding, they would appear to pass. Major Charters adopts Mr. Sharpe's opinion, that these strata dip from Mont Blanc, and is therefore an advocate for his theory; but Professor Forbes has, on the contrary, disputed, in an able paper, all Mr. Sharpe's statements, and vindicated the accuracy of the Swiss observers, more especially of M. Favre, whose laborious excursions, unchecked by danger and fatigue, and continued over many years, fully merited the confidence demanded for him. In this paper Professor Forbes points out, as a striking example, the secondary beds of limestone on the road to the Chapeau, which, from some unexplained reason, Mr. Sharpe had not examined; and, as I was myself at Chamounix, I hoped to have verified this position of Professor Forbes by personal investigation, and did so to a certain extent, though a severe fit of illness somewhat restricted my observations. The beds of limestone at the Chapeau certainly do dip towards the gneiss, the beds or folia of which rise above at a higher angle than those of the limestone; but as the junction is concealed by detritus, no positive conclusion could, in my opinion, be drawn from this circumstance. Reflecting, however, that M. Favre's great discovery of anthraxiferous beds resting horizontally on the peaks of the Aiguilles Rouges proved that at least the secondary rocks had there been deposited upon crystalline rocks, and subsequently lifted up with them, thus affording an argument against the actual underlying of such rocks by probably even more recent strata, I wrote to M. Favre on the subject, and I shall now give an abstract of his very interesting reply. In the summer he had visited, partly with M. De Verneuil, the Valley of Chamounix, and had also studied the works of Sharpe and Forbes; and after careful investigation he states that the rocks, wherever visible, confirm the conclusions to which he had come in 1846 and 1847, namely, that the beds of limestone are nearly vertical at the base of the Aiguilles Rouges, and dip at a high angle under the chain of Mont Blanc, the crystalline schists reposing upon them, and therefore dipping also under the chain. (See fig. 1.) In respect indeed to this limestone, M. Favre states that the Belemnites which are found in the more schistose beds are arranged parallel to the planes of division, which therefore cannot be taken for planes of cleavage, but must be true planes of bedding. At one point the distance from the calcareous rock to the crystalline schists was only 3·2 feet, and a plumb-line suspended from a point in the gneiss above would fall far within the calcareous area. M. Favre considers the representation by Studer of the bent-up limestone between the Aiguilles Rouges and Mont Blanc Ranges incorrect, and gives a section in which the beds are horizontal on the top of the Aiguilles Rouges, then rest at a high angle on their flanks, and dip under Mont Blanc;—a section also opposed to the views of M. Frêtz, who, by introducing the anthracites between the jurassic strata and the schists, makes the phænomenon one of inversion.

So far it would appear that little more could be desired to resolve this disputed question, and to establish as a fact, contrary to the opinion of our late President, that the jurassic rocks, composed of strata of varied mineral composition, do dip under the crystalline rocks; and that little has since been supplied by our fellow-member Mr. Ruskin, who, in a truly practical manner, had a shaft

Fig. 1.—*Relative position of the Limestone in the Valley of Chamounix according to M. Favre.*



1. Jurassic rocks.
2. Anthraxiferous rocks.
3. Crystalline schists.
4. Protogene.

sunk through the intervening detritus and discovered the crystalline schists reposing upon the jurassic beds;—a beautiful fact communicated to me by letter, and exhibited in the subjoined cuts from Mr. Ruskin's drawing. (See figs. 2 & 3.) We must remember that Dr. Buckland, as well as Saussure and others, came to this conclusion before, and deduced from it the comparatively recent origin of the granite of Mont Blanc; but, admitting the facts as stated so well by M. Favre, and represented by Mr. Ruskin, we may still hesitate to admit that the crystalline schists ever reposed as non-metamorphic rocks on the jurassic strata; indeed, there is no gradual progress of metamorphism to show that such could have been the case. Let us remember that as we pass through the Jura, say, for example, by the Val Travers to Neufchatel, we enter on a disturbed district, many portions of the rocks being evidently in an altered position,—a fact which has been strongly urged by Professor Voigt, in an interesting account of Mont Salève, as being characteristic of the Jura; whilst, as Dr. Lombard has pointed out, the occurrence of the same thermal phænomena at the two extremities of the Jura chain where it approaches the Alpine region marks out the limits of great disturbance, the portions of jurassic strata which were deposited between the outer belt and the inner focus of disturbance having been thrown necessarily into very abnormal positions. Rejecting then the cleavage-planes in the jurassic strata, but admitting it in the gneiss, and combining the uplifting of the Aiguilles Rouges on the one hand with that of the Alps on the other, there does not appear any reason why these appearances should be considered anomalous, or the facts disputed. I should, however, add, that Professor Rogers still denies a regular

Fig. 2.—*Section of the junction of the Gneiss and Limestone at the foot of Mont Blanc.*

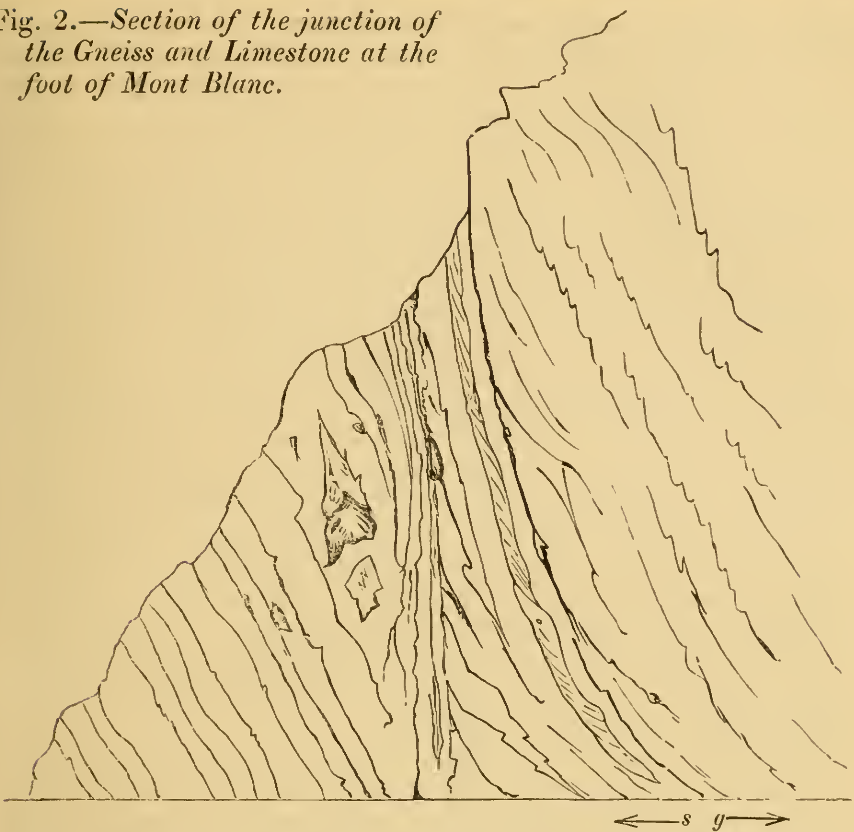
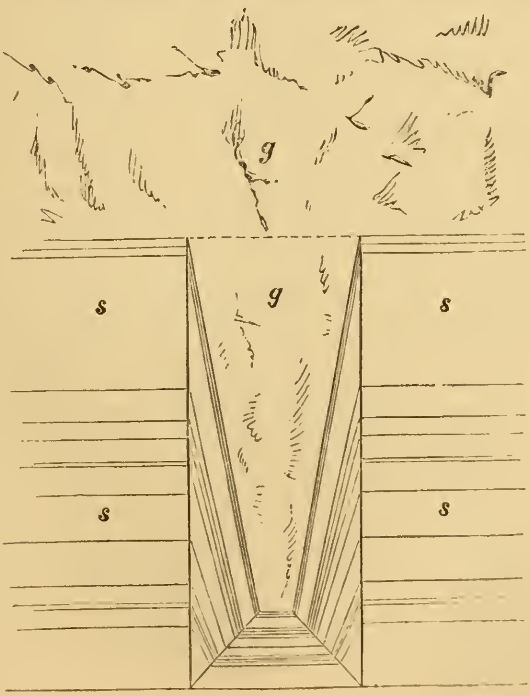


Fig. 3.—*Perspective diagram of an excavation made by Mr. Ruskin through the Limestones and Shales underlying the Gneiss.*



g. Gneiss, very rotten at the plane of contact. *s*. Stratified beds of yellow and brown limestones, associated with beds of clay, more or less slaty and micaceous.

vertical foliation, represents it as fan-shaped, and explains it upon his own principles; and that M. Favre has not been able to detect the uniformity of cleavage over large spaces which Mr. Sharpe describes. Such discrepancies as these may well occur in a region like the Alps, which cannot be explored, as Professor Forbes so justly observes, in a few days, but requires the conjoint exercise of high physical and mental powers continued for many years.

Passing now to the subject of Cleavage, which I have reserved to the last, I necessarily refer first to Professor Sedgwick, who, in his description of the rocks of Cumberland and Wales, read to our Society in 1835, entered into the general theory of the structure of large mineral masses, and necessarily into that of cleavage, the planes of which he clearly distinguished from those both of stratification and of joints. The highly fissile rocks he was then examining naturally led him to explain this peculiarity of structure by the theory of crystallization; and, although such rocks cannot be looked upon as large crystals, an idea which does not appear to me to have been ever entertained by Professor Sedgwick, there is certainly an analogy between the planes of rocky and of mineral cleavage, as the mechanical pressure which has produced the one is replaced by the force of affinity in the other, the cleavage-planes of a crystal indicating the directions of the attractive forces, just as those of rocky cleavage do the direction of pressure.

Mr. Sharpe takes his starting-point from this paper, though without admitting the principle of a true crystallization. His first step—and the thought was a happy one—was to connect the distortion of organic remains with the cleavage of the slaty rocks containing them. Professor Phillips had, as stated by Mr. Sharpe, before pointed out the distortions of both shells and trilobites, and ascribed them to a creeping movement of the particles of the rock along the planes of cleavage; but Mr. Sharpe shows, from many examples, that the distortion of shells is the result of the two conditions of any compressible body under pressure, namely, expansion in one and compression in the other direction, and by combining this with other phænomena, he arrived at the conclusion that the direction of the pressure producing contortions is perpendicular to the planes of cleavage. This connexion of the cause of contortion with that of cleavage is the chief merit of the paper; and the objection of Professor Rogers, that, if the contortions be merely the mechanical effects of pressure, they differ in character from the molecular rearrangements of particles necessarily attendant upon cleavage, may be readily answered by stating that, whilst a body yields to pressure, the molecular action does not commence, but, when the limit of condensation and expansion has been attained, the molecular action will commence and the cleavage-planes be produced. In a similar manner, the objection of Professor Rogers founded on the regularity of cleavage-planes when passing through contorted rocks—namely, that as a parallel force acting on curved surfaces must necessarily meet that curve at different angles and therefore could not give rise to a uniform cleavage,—may be answered; for, whilst the beds admit of yielding, as they must do in the process of contortion, the molecular action will be slight; but, when the yielding has ceased, there will be either a force of tension or one of compression, as in an arch, and the resulting cleavages take place in radiating planes; or, should the whole contorted strata form one mass, the cleavages would take place uniformly through that mass without reference to the contortions. These objections are urged by Professor Rogers in an able paper read before the Royal Society of Edinburgh, in which he repeats his former views respecting the folding of strata as a consequence of the supposed wave-like motion of an internal liquid mass, and states that the cleavages are always parallel to planes passing through the anticlinal and synclinal axes of the waves. You are also all aware of the ingenious observations of Mr. Sorby, ascribing cleavage in part to the parallel arrangement of planes of mica and other uniaxial particles within the mass; and assuredly, so long as a mass is capable of condensation, the planes of mica, like the fossils, must fall into planes perpendicular to the direction of pressure, or, if acted upon by a current whilst they are being deposited, will tend towards such planes; in a recent paper, Mr. Sorby states that it was a misconception of his views to suppose that he ascribed cleavage solely to the presence of plates of mica, as he had recognized it in rocks not containing mica, though he considers the presence of mica as tending to produce a much more perfect cleavage. Professor Tyndall, by a series of interesting experiments, has shown that cleavage can be produced in any substance by pressure, and that the planes of cleavage will be perpendicular to the direction of that pressure. Since then a most interesting work has been published by Hausmann of Göttingen, in which he collects together numerous examples of the molecular rearrangement of solid bodies under the influence of continued heat, as, for example, in bar-iron, where a granular structure is changed into a laminated one, without any change of the external form; and, when we consider that in most geological phænomena heat must have been combined with pressure, we may well believe that whilst heat facilitated the development of molecular rearrangement, pressure determined its direction. Such indeed appears to be the necessary result of the great physical law of action and reaction, as the particles, when thus pressed together, necessarily react in an opposite direction, and thus a force of reaction is produced sufficient to overcome the ordinary cohesive force of the body: Professor Rogers' objection, that such cleavage ought to be exhibited in coarse sandy rocks, as well as in those of finer materials, whereas it is observed to miss the coarse beds in an alternating series of coarse and fine strata, not being valid, as cohesive force must also be in action to hold the particles together in order that any satisfactory cleavage should be exhibited, and the defect of cohesion in sand prevents therefore the development of cleavage. The experimental proofs which have been adduced of the true origin of cleavage have recently been supported by an interesting mathematical demonstration, by the Rev. Professor Haughton, of the result of pressure in modifying the forms of fossils; the first great fact on which Mr. Sharpe founded his theory being thus brought within the bounds of calculation.

I have treated this subject at some length, because the two papers of Mr. Sharpe upon cleavage must always be reckoned amongst his most striking contributions to science; though it is feared that his success in explaining cleavage and assigning it to an efficient cause may sometimes have induced him to push the fact itself beyond its true limits, as in his paper on Scotland in the Transactions of the Royal Society, and in his paper on the Alps. I have thus endeavoured to do justice, though imperfectly, to the labours of Daniel Sharpe, and I will only add, that his quiet humour, his manly straightforward assertion of truth, and his well-known liberality and benevolence endeared him to us as a friend, whilst his shrewd discernment, his accurate observation, and his extensive knowledge made us admire him as a philosopher and geologist.

Sir Alexander Crichton, second son of Mr. Alexander Crichton, and grandson of Mr. Patrick Crichton, of Woodhouselee and Newington, Mid-Lothian, was born in Edinburgh on the 2nd of December, 1763. He received his elementary education in the Canongate and High schools of his native city, and afterwards matriculated at its University. He was about the same time apprenticed to Mr. Alexander Wood, a surgeon of considerable eminence in Edinburgh.

In 1784 Mr. Crichton went to London for one year to attend the hospitals, and to prosecute his studies, more particularly anatomy, in the schools of the metropolis. At the expiration of the year he went to Leyden, in company with Mr. Robert Jackson, a young army surgeon, who afterwards became favourably known for his writings on subjects connected with Military Surgery. Although brought up to consider the practice of Surgery his vocation, Mr. Crichton thought it advisable to submit himself to the necessary examinations before the professors of Leyden University for the Degree of M.D., which he obtained in July 1785. (The subject of his inaugural Thesis was "De Vermibus Intestinorum.")

After passing a short time in Holland, he proceeded to Paris to perfect himself in the French language, and avail himself of the falities for advancement in every department of medical knowledge which that capital afforded. In the summer of the following year Dr. Crichton was prevailed upon by his friend, Dr. Pringle, to give up his original plan, and to accompany him to Stuttgard, in order that they might study the language of the country. At the expiration of three months, agreeably and profitably spent, the two friends separated, Dr. Pringle to return to Alnwick, and Dr. Crichton to proceed to Vienna, where he remained six months, and gained much practical information by daily attendance at the General Hospital of that city. The University of Halle in Saxony was next visited, where Dr. Crichton resided three months in the house of the celebrated anatomist Meckel, and thence proceeded to Berlin; and in March 1788 to Göttingen, which he left on the 20th of September of the same year. Having thus spent upwards of three years on the Continent, devoting his time almost exclusively to professional studies and in the society of many of the most eminent professors of the day, he came to London and established himself as a surgeon, becoming a member of the Royal College of Surgeons (7th May, 1789), but renounced the practice of surgery two years after, as he never liked the operative part: and, taking advantage of the Leyden degree of M.D., he became a licentiate of the London Royal College of Physicians (25th June, 1791). He was soon appointed Physician to a respectable Dispensary in Featherstone Buildings, Holborn, where, with the co-operation of Dr. Bradley, he established a School of Medicine "upon a plan similar to that at the University of Göttingen," and gave clinical lectures twice a week upon the more remarkable or instructive cases that presented themselves. Subsequently he was elected Physician to the Westminster Hospital, and there for many years gave courses of lectures to the students on the Practice of Medicine, on the Materia Medica, and on Chemistry.

He married, in September 1800, Miss Dodwell, the daughter of Mr. Edward Dodwell of West Moulsey, Surrey.

In the same year he was elected a member of the Royal Society. He had been appointed Physician to the Duke of Cambridge, a title he was kindly permitted to retain, notwithstanding his subsequent long absence in Russia. In 1803 Dr. Crichton was invited to be Physician to the Emperor Alexander of Russia, but it was not until August 1804, that, after repeated promises of encouragement and of remuneration, he was induced to quit the advantageous position he had attained in London. He was most kindly received, and enjoyed the full confidence of the Imperial Family to the last. The indifferent state of health of Mrs. Crichton, as well as of his own, resulting chiefly from the severity of the climate, and in the Doctor's case from constant fatigue and anxiety of mind, forced him to petition for permission to retire from the service of his Imperial Majesty. In the hope of obtaining the confirmation of an implied leave of absence, Mrs. Crichton in 1809 went to London with her children, leaving her husband to settle matters in St. Petersburgh and follow as soon as he could. But to his utter dismay, in every interview with the Emperor, his Majesty seemed more and more determined to bind him by the fairest of promises to his service. All this occupied more than a year; at last the separation, so painful to both of them, was terminated only by the return of Mrs. Crichton to St. Petersburgh. At length, after repeated refusals and many delays, Dr. Crichton obtained permission to retire in the summer of 1819. During his service of fifteen years many honours and decorations were bestowed upon him, and he also received testimonials of high esteem and friendship from other members of the Imperial Family. He was recalled the following year in consequence of the illness of the Empress Alexandrina, but returned in the course of a few months. Sir Alexander Crichton was Knight Grand Cross of the Russian orders of St. Vladimir and of St. Anne, and Knight of the Red Eagle of Prussia.

He became a Fellow of the Geological Society in 1819, as also of the Medico-Botanical Society. He had become a Fellow of the Linnean in 1793, and of the Royal Society in 1800, and was a Member of no less than fourteen Foreign Societies; and it may be mentioned to his honour, that he received his first Russian distinction, as Knight Grand Cross of the Order of St. Vladimir, for his services during an epidemic in the south-east provinces of Russia. Having been permitted to wear the insignia of his Russian orders, he was knighted by King George IV. in the year 1821.

His works were principally Medical, but he published an essay in the Annals of Philosophy, "On the Climate of the Antediluvian world," and in the Geological Transactions a short paper, which was read on the 2nd of February, 1826, on the Taunus and other mountains of Nassau. The chain of the Taunus is described as consisting of talc and quartz slates on its south side, and of grauwacke strata, more or less schistose, on the north side, the talc slates dipping to the north-west into the mountains, and passing out on the south brow of the chain, whilst the grauwacke strata rise up from the valley in a south-east direction. The grauwacke occupies much of the Duchy of Nassau, and is occasionally overlaid by limestone. Trap and porphyritic rocks are involved in the sedimentary rocks, and appear to have been the proximate cause of much disturbance; whilst the mineral waters of the district are well known. A few palæozoic fossils from these rocks point to an age more recent than the Silurian. A brief notice also of the tertiary deposits of the valley of the Marne is given in this paper.

Those who remember Sir A. Crichton as in those memorable days he appeared in the meeting-room of the Society, cannot have forgotten the frank and manly bearing which was his peculiar characteristic, and which must have contributed, with his great talents, to obtain for him so many proofs of high esteem from persons of all classes.

Sir Benjamin Fonseca Outram, C.B., M.D., F.R.S., F.G.S., Inspector of Naval Hospitals and of Fleets, is said to have been born at Kilham, near Bridlington in Yorkshire, about 1774, although baptized at Gravesend, Kent. Early destined for the medical profession, his noviciate commenced at Gravesend. Thence he removed to London; and at Guy's and St. Thomas's Hospitals spent some time, and laid claim to some improvement in the treatment of persons apparently drowned. Induced by a love of adventure and change of scene, he became desirous of entering into the Medical Service of the Royal Navy, but was for a time deterred by the depressed state of that department. Eventually Mr. Outram resolved to try it for a time; he therefore, in 1794, became assistant-surgeon (or, as then termed in both services, surgeon's mate) in the 'Iris' frigate, with Captain, afterwards Sir William Hargood. Here he continued nearly two years; his scenes of service in this ship were sufficiently varied and the passion for change pretty well gratified by cruising in the North Sea, Baltic, English Channel, on the coast of Africa, at Teneriffe, and Quebec. In 1796 he was promoted to the rank of surgeon of the 'Harpy' brig of war. Her sphere of service was chiefly on the coast of Holland and in the Channel. From her he was removed in the following year, 1797, to 'La Nymphe' frigate of 36 guns, Capt. Cooke, in which some sharp service was experienced: one of the chief occasions was in company with the 'St. Fiorenzo,' Sir H. B. Neale, when they attacked and captured off Brest, in fine style, and in sight of the French fleet, two frigates of that nation, 'La Résistance' and 'Constance.' For this action he received the war medal and a clasp.

Mr. Outram was soon afterwards removed to another frigate, the 'Boadicea,' Captain, afterwards the distinguished Sir Richard Keats. In her, during the years 1798–99, 1800, all that a frigate could do was done, in the most arduous of all services, the blockade of the French ports. In 1801, Mr. Outram removed with his Captain, into the 'Superb,' 74 guns. Here, in company with the 'Venerable,' of similar force, and 'Cambrian' frigate, a fleet of merchantmen was seen safely to its destination, a Spanish corvette was captured, and several English merchantmen that had fallen into the hands of the enemy, retaken. The Mediterranean now became the chief scene of operations, and Capt. Keats established his fame by one of the most brilliant, skilful, and successful attacks upon an overwhelmingly superior force, that occurred during the war. It is too well known in naval history to require description here. The surgeon of the victor ship exhibited other than professional merit on this occasion. During the engagement, some cartridges exploded near the magazine door, when Mr. Outram, who happened to be near the spot, instantly closed the door, and, taking such other steps as were necessary, prevented at least the possibility of further mischief. The late Rear Admiral Samuel Jackson, the First Lieutenant of the 'Superb,' bore testimony to his presence of mind on this occasion. This action added another clasp to his medal; but the peace threw him, with many others, into private life.

On the recurrence of hostilities in 1803, he became surgeon of the 'Matilda' hospital-ship, at Woolwich; but that line of employment being inactive, application was made for a sea-going vessel, and he was appointed to the 'Euryalus' frigate, Capt. the Hon., afterwards Sir Henry Blackwood. In the following year he became surgeon of the 'Royal Charlotte Yacht,' Captain Towry, in attendance upon His Majesty, George III., at Weymouth.

In 1809 he received a similar appointment to the 'Royal Sovereign Yacht,' Sir H. B. Neale, to remain in waiting on the Princess Amelia and Royal Family, and he attended, 1814, Louis XVIII. and suite from Dover to Calais. Amid the changes introduced into the service in 1841, Dr. Outram became an Inspector of Hospitals, on the retired list. In 1850 he was knighted, and became Companion of the Bath.

As he advanced in life, he sought recreation and satisfaction of his innate love of adventure and travelling on the Continent, where he often proved a most valuable friend in sickness to many of his fellow-countrymen. He never published any book of science, though he took much interest in its advancement, and he was on his way to Glasgow to attend the Meeting of the British Association, when he was attacked by cholera, from the effects of which he never fully recovered. He died on the 16th of February, 1856, at the age of 82. His name is now familiar to all from the distinguished services in India of his relative Sir James Outram.

Nathaniel John Larkin was born in London, 5th December, 1781. At the age of nineteen he went to the Orkney Islands, to establish a straw-plat manufactory, which he superintended for some years. He subsequently returned to London, and became noted for his models of crystals, illustrating Hauy's *Traité de Minéralogie,* and likewise the views of Dr. Wollaston, Professors Mohs and Jameson, and other writers of scientific eminence. He constructed a cube of spherical molecules, uniform with the tetrahedron and octahedron of Dr. Wollaston, from whom he received much friendly encouragement and assistance. He also arranged a very complete and comprehensive set of Geometrical Solids, and published three books in explanation of them, the most important of which was his 'Introduction to Solid Geometry, and to the Study of Crystallography;' a work which appeared in the year 1820. About this time he was elected a Fellow of the Geological Society, to the President (G. B. Greenough, Esq.) and other members of which he dedicated his book. He was afterwards presented by them with a Life-Fellowship of the Society, and was once a candidate for the post of Assistant-Secretary. He was the first Secretary of the Society of Civil Engineers, then (1825) meeting in Buckingham Street, Adelphi. He died on the 21st of October, 1855, being in the 74th year of his age.

Archdeacon Hare was a member of Trinity College, Cambridge, and, though not a practical geologist, merits on our part a brief notice, as he was a friend of Sedgwick, and joined our Society under the influence of that enthusiasm for the truths of nature which was the ordinary result of attending the lectures of our distinguished member at a time when he, like Dr. Buckland at Oxford, was beginning to unfold the beauties and expound the principles of Geology at Cambridge. He graduated in 1816, was a fellow and tutor of his college, and attained a high character as a classical scholar and literary man. He was associated with the present Bishop of St. David's in several literary works, and especially in the difficult one of translating Niebuhr's History of Rome. When it is remembered that the German class of historians, then little known in England, is characterized by the unhesitating sacrifice of all traditionary fables, however poetical in themselves, and however endeared by the associations of early life, at the shrine of truth, we may hail them as our fellow-labourers, for in no science is the student more subject to have his favourite fancies rudely shaken than in Geology. Archdeacon Hare was also one of the Authors of

'Guesses at Truth by Two Brothers,' a collection of striking and original observations on moral and metaphysical subjects.

He left college to enter on pastoral duties as rector of Hurstmonceaux in Sussex, and was afterwards made Archdeacon of Lewes. Occasionally he visited the University as one of the Select Preachers, in which capacity he attracted large audiences by the fervour of his manner and the copiousness of his language. His tastes had probably a leaning to German metaphysics, rather than to any branch of physical science, but without doubt he was a good scholar, a bold thinker, and an eloquent preacher, whilst his personal character was so estimable that those even who objected to his theological opinions were disarmed of all angry feelings, and a large circle of friends was drawn round and deeply attached to him.

Dr. Ure was an honorary member of the Society, and better known for his great abilities both as a speculative and practical chemist than as a geologist. In his own catalogue of his principal writings, published between September 1817 and July 1830, he enumerates no less than forty distinct treatises or essays, in addition to his great Chemical Dictionary, which had then gone through four large editions, and his New System of Geology, and he observed respecting them, "that almost every department of chemical science had in succession been made the subject of a distinct investigation." After that period, in 1834, a paper on the analysis of the Moira Brine Spring, with researches on the extraction of bromine, was published in the Philosophical Transactions; in 1835 the Philosophy of Manufactures; in 1836, the Cotton Manufacture of Great Britain compared with that of other countries, and in 1837, his very detailed work on the 'Arts and Manufactures,' since greatly enlarged in the edition of 1853; and in addition to these distinct writings, several chemical essays in 'The Penny Cyclopædia,' and in the scientific journals, as also many pamphlets of a very varied character, some being medical, and others politico-scientific. Of such a number of writings, many possessed originality and great merit; and in respect to his New System of Geology, his own words explain sufficiently its bearing, as he has observed that in this work "he endeavoured to show how chemical physics may be made to explain some of the most mysterious phænomena connected with the structure of the earth and its organic remains." At that time chemistry had hardly been recognized as one of the elements in geological research, but now the labours of such men as Bunsen and Delesse have proved that without its aid we cannot expect to obtain a perfect knowledge of all the phænomena which a study of the earth's history through past ages brings before us. He was a member of the Astronomical Society, and for many years Professor of Chemistry in the Andersonian University.

Colonel Lloyd.—The name of the late Colonel Lloyd not having been noticed in the preceding obituary, it is but just to devote a few words to his memory as a Fellow of our Society.

In November 1827, Mr. J. A. Lloyd, who had for some time served in the personal staff of General Bolivar, was directed by him to survey the Isthmus of Panama, for the purpose of determining the most eligible line of communication across it, whether by road or canal. The result of this difficult operation of levelling across the Isthmus, and the determination of the respective levels of the Atlantic and Pacific Oceans, as also of the amount of elevation of the Isthmus itself, were published in the Philosophical Transactions for 1830, and were considered highly creditable to the zeal and ability of Mr. Lloyd. The notes of the collateral observations made by Mr. Lloyd, on the geography and statistics of the region, were communicated to the Geographical Society, and published in their Transactions for 1832. Prior to this time he had been appointed to a government situation in the Mauritius, but having again returned home, he was appointed a special commissioner for the Exhibition of 1851, and in that capacity he brought forward his proposals for establishing colleges of arts and manufactures for the better instruction of the industrial classes, and instanced to Earl Granville, as models for such institutions, the 'Conservatoire des Arts et Métiers,' of Paris, and the 'Ecole des Arts et Métiers,' urging with considerable force the advantage which society at large would derive from the foundation of a museum of arts and industry for the public instruction of the people. Having gone through the historical details as well as those referring to the objects and routine of instruction, proposed and followed by these two practical French establishments, Mr. Lloyd impressed upon his Royal Highness Prince Albert and the Royal Commissioners the vast importance of preventing the dispersion of the many works of nature and art collected at the Exhibition, and of making them the nucleus of a great national museum of practical science and art, and recommended that the whole of the balance of the available funds derived from the Exhibition of 1851 should be devoted to the endowment of a College of Arts, Sciences, and Manufactures, of which the museum should be an auxiliary establishment. With this college he proposed that the Museum of Practical Geology, the Schools of Design, and other insulated departments should be blended, and their professors and teachers become its instruments for the diffusion of practical knowledge. These propositions have since made rapid advance in their practical development. Mr. Lloyd was now appointed Chargé d'Affaires and Consul General to the Republic of Bolivia, and returning to the scene of some of his former labours, he sent home two reports on the country, which were submitted by the Government to the Geographical Society. In the last of these papers he described his arduous journey to the Cerro Pasco Coalfield in Peru, which occurs at the height of 14,278 feet, and portrayed very graphically the primitive manners of the inhabitants of this remote settlement, which is nearly isolated by its position from the rest of the world. He was indeed an enterprising and energetic man, possessed of considerable powers of observation, and, being an able sketcher on horseback, was capable of effectually illustrating his observations; and his papers contained numerous references to mineralogical and geological phænomena. Being at home on leave, he was appointed to go on a special mission to Circassia, but was attacked on his way through the Crimea with cholera, and, being obliged to return to Constantinople, died there on the 10th of October, 1854. His designation as Colonel probably represented the rank Mr. Lloyd once held in the army of Bolivia: he was a Fellow of the Royal Society, a Fellow of the Geographical, and a Member of the Institute of Civil Engineers.

Of our foreign members we have lost, in M. Constant Prévost, one who has been long classed amongst the most eminent scientific men. He was born in Paris, 6th June, 1787, his father, M. Louis Prévost, being at the time Receiver of the Rentes of Paris, and his mother, the daughter of a distinguished family of civilians. M. Louis Prévost died on the 30th August, 1793, leaving two children, a son and a daughter, to the care of his widow, who, being a woman of the most elevated character and noble mind, devoted herself to the education of her children. In 1804 his daughter died, and Madame Prévost concentrated all her solicitude and her efforts on the education of her son, who, thanks to her care, received instruction of the most sound and varied character. In July, 1816, Madame Prévost contracted a second marriage with M. Bevière, whose father was at once Senator and Dean of the Faculty of Mayors and Notaries of Paris. M. Bevière manifested towards his son-in-law a true paternal affection; and, when it is considered how powerful the claims of his family were both on the father's and mother's side, it will be admitted that, like his friend, the celebrated Blainville, M. Prévost abandoned the distinctions and the wealth which he might have easily commanded in civil life, for the less certain, but still more noble rewards of science. He commenced his scientific studies in the Central Schools, which have replaced the ancient Colleges of France, and for several years was amongst the most distinguished students, carrying off the first prizes. He attended the lectures of Cuvier, Brongniart, and Dumeril, and, charmed by their eloquence, felt the most ardent taste for the natural sciences gradually developing itself within him.

In 1811 he took his degree in Letters and Sciences at Paris, and for a time devoted himself to the study of medicine, having been admitted into the class-room of Cuvier, where he studied, in conjunction with his friend Blainville, human and comparative anatomy and general physiology. In 1812 he attended the lectures of Cuvier at the College of France, as well as those of Desfontaines, Jussieu, Gay-Lussac, Biot, and Thenard. The impulse of his taste at first led him to the study of Natural History, and he was engaged with Blainville in a work on fishes, but he was soon more powerfully drawn towards the exclusive study of Geology, for which his varied attainments had so eminently prepared him. In fact Brongniart had early distinguished him amongst his pupils, and selected him in 1808 to accompany him on a journey to the western provinces of France, and again in 1812 on a visit to Germany. Having afterwards returned to Germany, he devoted himself from 1816 to 1819 to the study of the Vienna Basin, in which he discovered a series of tertiary deposits, very similar to those of the Paris Basin, thus extending the discoveries of his early masters to other and distant regions. He published his work on the Vienna Basin in 1820, and, comparing its deposits with those of Paris, pointed out that they were either more recent than the Parisian beds, or at least equivalent to the upper portion of them, thus advancing an opinion now recognized as a fact, that there are tertiary deposits more recent than any of those which constitute the Paris formation, and suggesting to geologists the means of more accurately determining the epoch of the tertiaries of Italy and of the South of France. In the next year he published a work on the Geology of Normandy, the coasts of which he had carefully examined with the view of determining the geological succession of the secondary rocks of this part of France, and comparing them with those of England, so that it has been justly claimed for him that he shared with the early English geologists in laying the first firm foundations of the science. From 1821 to 1829, he was Professor of Geology at the Athenæum at Paris. In 1820 he had first communicated his observations on the occurrence of marine shells in the muds of freshwater deposits, and of freshwater shells in the marine deposits of the Paris Basin; and in 1829 he resumed the discussion of these facts; and, opposing the theory of alternating elevations and depressions of the surface, he maintained that such mixtures of the organisms of freshwater and marine life were the consequence of river-freshets on the one hand, and of tidal overflows on the other, in a large estuary. This theory he afterwards applied to the Sub-Pyrenean Basin in his paper on the bone-beds of Sansan, near Auch. In 1829 he was the projector and one of the founders of the Geological Society of France, as has been commemorated by M. Deshayes in the following very forcible words: "It so chanced," he says "that M. Prévost, his brother-in-law, M. Jules Desnoyers, and myself, were lodging together in the Rue de Paradis, when Constant Prévost conceived the idea of founding an independent society, under the title of The Geological Society of France, which was intended to advance and spread abroad the science by collecting together its scattered elements. The idea of such an association was eagerly embraced by a small number of the most eminent men of the epoch, who became thus the first founders of the Society. Around them were speedily grouped a large number of native and foreign men of science, who felt honoured by being associated in their labours. The success of this happy thought of Constant Prévost is no longer doubtful, and more than five hundred colleagues, spread over every part of the earth, will be associated in the grief which all must feel at the loss of our founder." How much must these words recall the early formation of our own Society, although the customs of our country have not permitted those public exhibitions of grief at the loss of its founders which are so characteristic of our French neighbours.

In 1831 he taught Mineralogy and Geology at the Central School of Arts and Manufactures. In 1831, through the influence of Cuvier, he was named Assistant Professor of Geology to the Faculty of Sciences, and soon afterwards he was named Honorary Professor of the same science. In this year also he was deputed to visit the volcanic island which had then suddenly appeared in the Mediterranean; and, having thus had his attention directed to volcanic phænomena, he proceeded to examine them in Sicily, near Naples, in Auvergne, and the Vivarais, the result of which was, that he announced himself an opponent of the views of Von Buch, regarding craters of elevation, and expressed his belief that in Vesuvius, Etna, Mont Dore, and the Cautal, the cones were merely produced by accumulations proceeding from successive eruptions of ashes and of lava streams. This abandonment of what had been his own previous opinions, he spoke feelingly of as a necessary sacrifice to what he considered truth, as he always entertained a high respect for Von Buch. In like manner he was opposed to Elie de Beaumont, on his theory of the elevation of mountain chains, M. Prévost not admitting an expansive force within the earth's crust sufficient to elevate mountain masses, and ascribing such apparent elevation to the gradual contraction of the nucleus, and to the cracking and consequent sinking of the crust on the one side, whilst on the other it necessarily rose, the disturbed portion moving as it were on an axis or hinge. That elevation and depression are generally coincident in any great movements of the earth's crust, few, I should imagine, can have a doubt; but it is right to observe that a force capable of raising a column of lava to the elevation of many thousand feet, would be also sufficient to raise a mass of land, supposing that the force of cohesion had been overcome and a fracture produced.

The great characteristic, however, of all M. Prévost's works was, that, in accordance with the principles of his illustrious friend De Blainville, he endeavoured to illustrate the past by the present, and that he even laboured to prove that the causes or forces which we now see in action are in their nature sufficiently powerful to have produced all the effects observable on the examination of the records of the past operations of nature, whether of a formative or of a destructive character,—a theory which, under the appellation of "the doctrine of recent causes," has become familiar to geologists from the works, especially 'The Principles of Geology,' published in 1832, of Sir Charles Lyell, and of whom Prévost thus speaks:—"I felt that to carry out effectually my researches on the shore of France, it was necessary that I should visit England, and there study the normal type of the secondary formations. In 1824, therefore, I visited, with my friend Mr. Charles Lyell, whose works and geological doctrines have since rendered his name so popular throughout the world, a part of the south and north of England, Cornwall, and almost all the shores of the Channel, from the Land's End to Brighton; I studied also a part of the coast and the Isle of Wight in company with Dr. Fitton, so well known by his 'consciencieux travaux.'" M. Prévost also read before the Academy of Sciences, in 1845, a memoir on the 'Chronologie des Terrains et du Synchronisme des

Formations,' in which he discusses the opinions of the most eminent of his predecessors, and maintains, with Humboldt and Von Buch, that the two great forces, aqueous and igneous, have acted simultaneously throughout the world's history, so that in every formation principally resulting from aqueous action or deposition there ought to be found evidences or results of igneous action also. He also greatly extends in this treatise the doctrine of the inflowing of fresh water, when he observes that "it is from want of reflection that fluvio-marine formations have been considered only local accidents of an estuary or gulf, as it may be affirmed that, in certain seas bounded by vast continents, the inflowing fresh waters produce more effect on the marine deposits than the sea-waters," and in support of this opinion adduces the fact, that plants brought by river action into the Gulf of Mexico have been carried to the coasts of Iceland and Spitzbergen. In fact, after discussing the various effects produced simultaneously in the present seas, and showing that at every preceding epoch similar variations in the effects produced at different localities were also simultaneous, he gives the characteristics for distinguishing the fluvio-marine from the purely marine formations of all ages; and in respect to the synchronism of aqueous and igneous forces, he says, "the results of the study of actual phænomena when applied to the explanation of ancient phænomena have demonstrated, as an incontrovertible truth, the synchronic action of the two principal causes, Plutonic and Neptunian, during all ages."

The peculiar care bestowed upon his works by M. Prévost, and his nervous dread of publishing anything not quite complete in his own estimation, have been thus recorded by M. Deshayes :—

"The works of Constant Prévost are numerous, and all of them of incontrovertible merit; among them there are some which, by their importance, place their author in the most elevated rank among *savans*: we ought to have a greater number; but he was one of those who blamed too much that precipitation which often induces persons to publish imperfect works. After having accumulated immense materials, he still retarded the moment of producing them, from the fear of being yet incomplete. Looking upon science with an eye too keen not to observe its defects and gaps, he still preserved the hope of perfection in time, and this was the reason he so constantly delayed the publication of his most important works."

On the 29th of April, 1836, M. Prévost was appointed Chevalier de la Légion d'Honneur, and was subsequently raised to a higher grade in that order. In February 1848, he was chosen a Member of the Academy of Sciences with a large majority. He died on the 16th of August, 1856, most deeply and sincerely lamented by all the great men with whom he had been so long and so closely associated; for, though he was, like Blainville, a warm disputant, whether maintaining his own opinions or attacking what he deemed the errors of others, he never allowed the heat of argument to degenerate into personal acrimony, but was at once candid and conciliatory to his opponents. He was generous in every respect, having liberally contributed to the Paris Museum his large collections, especially those made in Sicily and Italy, consisting of more than 6000 specimens of recent and fossil species, as well as of minerals, and the series of his collections connected with his researches in the Vienna basin, the shore of France, &c.; and he was ever most liberal in the application of his private fortune to the purposes of science.

Of the other members who have been removed by death from amongst us, I can only speak in terms of general respect, as, in their cases, I have not been able to collect the materials for even a brief record of a practically useful life. Of the Rev. Mr. IMAGE, however, I may say that he was a zealous collector, who at all times was willing and desirous that his collection should be studied and made use of by men of science.

There is one other name which, in addressing the Geological Society, I feel bound by feeling and by duty to mention, though it is not that of a Fellow of the Society,—I mean the name of HUGH MILLER. It will be remembered that at a time when a strong interest in the study of Fossil Ichthyology had been aroused in this country by Agassiz, a hardy son of labour discovered in the quarries of his native Scotland the relics of many an inhabitant of its ancient seas; and, possessing the keen intellect and the well-tutored mind characteristic of so many of his countrymen, he not only discovered, but he described them, and gave to the world the 'Old Red Sandstone.' This, though not the first literary product of his pen, was a work, like White's 'Selborne,' combining accuracy of information with a charming simplicity of style which suited all tastes, and commanded the approbation of the most general as well as the most scientific readers. From that moment to the day of his death, Hugh Miller was considered a geological brother by the most eminent cultivators of the science. In his subsequent work, 'Foot-Prints of the Creator,' Mr. Miller gives much interesting and valuable matter in reference to the discovery, history, and true position amongst Fishes, of the *Asterolepis* of Stromness, and describes with considerable ability the segments, and their analogues, of the cranial region. The far greater portion of the work is, however, devoted to a reply to the reasonings of the author of 'Vestiges of the Creation,' and to the somewhat mystical writings of Oken; and it was doubtless on that account that the name of the work was suggested to him by a reverend friend; though, alas! how vain every attempt has hitherto been, and ever will be, to discover the primæval laws of creation. It is possible, as Miller has done, to demonstrate that the development theory has been pushed too far, or that the embryonic theory has been sometimes applied without judgement; but we are still as far as ever from any solution of the great problem of creation. The posthumous work of Miller, called the 'Testimony of the Rocks,' is also rich in valuable facts, but at the same time it is so deeply controversial as to become even polemical. Would that he could have calmed his anxious spirit, and allowed those, and they are few, who are still determined to maintain that the wisdom of God shall be made known to man only by one class of teaching to weary out their own energies, rather than, by a disputation, sometimes bitter in its tone, to encourage them by imitating their intolerance! It is indeed painful to think that any such cloud should at the last have passed over the horizon of Hugh Miller's scientific life, and that a spirit so energetic and an intellect so bright and vigorous should have been abruptly and prematurely quenched for ever.

This appears to me to be the fittest moment for endeavouring to remove that feeling of having been unjustly condemned by my predecessor, Mr. Hamilton, in his Anniversary Address, which Professor Sedgwick has so strongly expressed. I have, indeed, been requested by Mr. Hamilton to state that he regrets having been led into an error in what he stated in his Address from this chair last year, respecting the motives which led to the publication by Prof. Sedgwick of his paper on the May Hill Sandstones in the 'Philosophical Magazine.'

Mr. Hamilton has addressed a letter to the Council on this subject, in which he says, that "as it appears that Prof. Sedgwick published his paper in the 'Philosophical Magazine' under the impression that it *had not been received or accepted* by the Council, he willingly acquits Prof. Sedgwick of any intention of infringing the rules and practice of the Society, and regrets having made the statement to that effect."

Such are the words of Mr. Hamilton, and it is unnecessary to add to so frank an avowal of an unintentional error anything beyond the confirmation of its accuracy.

It was indeed well known to every member of the Council that the paper on the May Hill Sandstone had been accepted and referred in the usual manner, as no one in the Council or in the Society could for a moment have desired to prevent Professor Sedgwick, whose labours had contributed so much to the progress of geology and to the honour of the Society, from frankly expressing his opinions on a subject not certainly free from difficulty, namely, the true base of the Silurian System. The desire of the Council was simply to keep the expression of that opinion within the limits of a scientific discussion, and to free it from any taint of personality. In such a matter dates sink into insignificance, as the real question is, does the present evidence require and justify that a portion of the Silurian System of Murchison should be separated from it, as defective in organic connexion with the rest, or not?

The actual proceedings of the Council being therefore known to Mr. Hamilton, he committed an error in supposing that Professor Sedgwick was equally aware of it; that error he admits, and it is hoped, therefore, that with that admission this dispute will terminate, and the old cordiality of the Society be restored.

Passing now to that review of Geological Progress which it is next my duty to undertake, and which I shall endeavour to make as brief as possible, I will commence by placing before you a notice by my predecessor, our late lamented President, of a memoir on the Geology of the Peninsula, as it may be deemed a supplement to his own papers on the Geology of Portugal. This and some other of his papers were confided to my care by Mr. Henry Sharpe, with the kind belief that they might be useful to me in preparing my own address; but the only use I could possibly make of them is to set them before you in their integrity, merely adding, where it appears necessary to do so, a few remarks of my own.

Mr. Sharpe observes, that our knowledge of the geology of the Peninsula has received a great addition from a memoir on Almaden and the neighbouring mountains by M. Casiano de Prado, which is published in the 'Bulletin of the Geological Society of France,' accompanied by full descriptions of the fossils by MM. De Verneuil and Barrande. The following formations are described in this memoir.

Lower Silurian (*primordial zone of Barrande*).—At Cortijos de Malagou, in the mountains of Toledo, some fragments of a Trilobite belonging to a new species of the genus *Ellipsocephalus*, found in a quartzose sandstone, are considered by M. Barrande to indicate the probable existence of this earliest fossiliferous zone in Spain; it has not yet been found in any other part of the Peninsula, and the evidence of its existence at this spot must be still considered incomplete.

Lower Silurian (*second zone of Barrande*).—The rocks belonging to this part of the Silurian system are widely spread out in the centre of Spain, and are very rich in organic remains. They are mostly dark schists, frequently accompanied by quartzites: the fossils correspond to a great degree with those collected in the Sierra de Bussaco, in Portugal, by Senhor Carlos Ribeiro, and described by Mr. D. Sharpe and Mr. Salter in the ninth volume of the Society's Journal; and, as in that locality, Trilobites and lamellibranchiate bivalves are particularly abundant. Many of the Spanish species are found in the west of France and in Bohemia, while comparatively few of the English Silurian species occur in Spain; thus strengthening the inference which had been drawn by Mr. Godwin-Austen from a similar important fact previously announced, namely, that the ocean in which the Lower Silurian beds were formed was divided, probably by intervening land, into a northern and a southern area, which were peopled in great part by different species of mollusks, a few species being common to both regions.

Among the organic remains, the obscure Fucoids (?) called *Bilobites* by DeKay, deserve especial notice, as they characterize certain upper beds of the Lower Silurian series, and in many parts afford the only clue which the geologist has to a determination.

Upper Silurian.—This part of the palæozoic series is as feebly represented in Spain as it is in Portugal, occurring here and there in a schistose form, with *Graptolites* and *Cardiola interrupta.* There are also in the Lower Silurian rocks of the Sierra Morena two species, *Chonetes striatella* and *Dalmanites Downingiæ,* which in the North of Europe belong to the Upper Silurians.

The *Devonian* series of beds, though scattered more irregularly than the Silurian, are of great importance in the central mountains of

Spain; they consist mostly of sandstones and quartzites, with some schists. Where the Upper Silurian formation occurs, the Devonian beds rest on it; elsewhere they lie immediately on the Lower Silurians. It appears from the organic remains, which are very abundant, that the beds belong for the most part to the *Rhenane,* or lowest division of the Devonian series; but the middle division occurs in some localities, and a few of the fossils indicate Upper Devonian beds also. The species found in Spain are, in great degree, those which are found in the Devonian beds wherever they occur, both in Europe and North America, and lead us to the conclusion that this formation was deposited in an extensive and continuous ocean—or, rather, I may venture to add to Mr. Sharpe's reasoning, on the shores of oceans subject to the same climatal and physical conditions. No vegetable remains have been found.

Carboniferous series.—The memoir of M. Casiano de Prado does not extend to this formation; but in the palæontological appendix some localities are noticed where large calcareous deposits, hitherto but slightly examined, contain *Producti* of this age.

Plutonic rocks are of frequent occurrence in the region described, but they offer no points of peculiar interest; they consist principally of granite and various forms of porphyry.

The whole region described has been subjected to so much disturbance, that the palæozoic rocks are for the most part in nearly vertical positions, and are nowhere found horizontal: a circumstance which renders the determination of the relative age of the beds a matter of great difficulty; and, but for the fossils contained in them, it would often be impossible to classify them. These difficulties are much increased by the want of even a tolerably accurate map of the country.

M. Casiano de Prado concludes his memoir with some very interesting remarks on the deposits of quicksilver: these are very rarely found in veins, but the quicksilver, mostly in the form of cinnabar (sulphuret of mercury), enters into the composition of the beds of quartzite, so that after it has been roasted off, the rock remains scoriaceous and so full of pores, that it frequently falls to pieces. In the richest mines the quartzites in which the cinnabar occurs are of the Silurian age; but at some less important spots they are Devonian. The slate-rocks rarely contain any mercury, and never in large quantities. The plutonic rocks do not appear to have had any influence on the presence or absence of the mercury; but in this respect I may add, that the sulphuret of mercury does not differ from other sulphurets, and further, that it cannot be absolutely inferred, from the apparent want of connexion of cause and effect in this and similar cases, that no igneous causes have really been in action in bringing the sulphur and the metal within the sphere of chemical affinity.

The first purely geological paper of the session was that of Professor Harkness on the Lowest Sedimentary Rocks of the South of Scotland. His first object was to trace out the axis of the Silurians in Dumfries-shire and to put it in relation with that portion of the axis which had been determined by Professor Nicol in Roxburghshire; and his inference from the comparison of these two portions of the axis is, that it has an E.N.E. and W.S.W. direction in the South of Scotland. The lithological nature of the rocks which actually constitute the axis, he represents as "purple grits, which have great resemblance to some of the bottom-rocks of the Longmynd. Resting uniformly on this axis, on each side, are thin-bedded sandstones alternating with grey and purplish-red shales, the purplish-red shales abounding more in the lower portion of the series than in the upper, where anthracitic and graptolitic shales occur; the purplish-red shales, therefore, marking a low zone in the Silurians of the South of Scotland. These three rocks extend over a considerable lateral space: Professor Harkness considers that their actual thickness is small, and that the multiplied stratification is due to flexure from lateral pressure, and the consequent frequent repetition of the same beds. He also adduces a decided slaty cleavage in the argillaceous strata as a further proof of pressure, although the absence of such cleavage in the gritty beds had been previously cited as an argument against the pressure-theory of cleavage, that absence being justly explained on the principle that arenaceous beds are less susceptible of cleavage than argillaceous, the reason of which I have already endeavoured to point out.

On the south side of the axis in Roxburghshire occur ripple-marked beds, which also exhibit what Professor Harkness conjectures must have been Sun-cracks from desiccation, and other appearances of a shore periodically laid bare, as also tracks of an animal in progression, which Mr. Salter has named *Protichnites scoticus*, considering it a Crustacean, with feet analogous to, but not identical with, that described and named by Professor Owen from the tracks in the Potsdam Sandstone. In the purplish-red shales, so low down in the series, the *Protovirgularia* and some obscure *Graptolites* occur; and at Dalton in Dumfries-shire *Graptolites* have also been found; but it is remarkable that the more decided graptolitic beds associated with anthracitic beds, which in the section are represented as normally existing at a higher level on both sides of the axis, have not been found on the south of the axis in Dumfries-shire. The existence of the *Protovirgularia* in the purplish-red shales at the bottom of the series in Dumfries-shire, as well as in the gritstone beds of Peebles-shire and the Barlae Flags of Kirkcudbrightshire, and its absence in the anthracitic and graptolitic schists, have induced the Professor to alter his former opinion, and to allot the former to a very low zone in the series, corresponding to a similar zone in Sweden and Norway, considering the graptolitic and anthracitic beds as belonging to a higher zone in the Lower Silurians. Of the whole, however, he appears to consider the purplish-red shales as the lowest in order, and therefore as indicating some of the earliest traces of animal life hitherto discovered, and that under conditions which prove, in the periodical desiccation of the shore, and in the markings of Crustaceans upon it, the close approximation to dry land.

In this interesting description of a district carefully examined, the disappearance of the graptolitic and anthracitic beds on the south side of the axis in Dumfries-shire is a very remarkable fact; for, though in following out laterally a series of beds it is neither unusual nor unnatural to find one or more of its members thin out and disappear, it is certainly very curious to find a whole series thus abruptly cease without any apparent physical cause for their disappearance. Speculation on early animal life must always be full of interest when based on carefully observed facts, and leading us, as in this case, to recognize in the state of nature, at an epoch beyond calculation remote, a prototype of the state of nature as we now see it.

Another paper by Professor Harkness, on the "Sandstones and Breccias of the South of Scotland subsequent to the Carboniferous epoch," next demands our notice; but, as I have in my possession a notice of this paper by Mr. D. Sharpe, in which he endeavours to explain the curious converging dip of the strata in the Corncockle district always from the older rocks, which do not exhibit the same phænomenon, and towards a central area, on a bold hypothesis, highly characteristic of our late President, and quite different from Professor Harkness's supposition of a subsidence within a limited area, somewhat like the hole of a crater of subsidence, by which the previously horizontal strata had been dragged down, and thus caused to converge or dip towards the same centre, I have thought it desirable to preserve it for the Society.

Professor Harkness, Mr. Sharpe observes, has minutely described several of the isolated patches of Red Sandstone occurring in the upper parts of the valley of the Annan, and in the upper and lower parts of that of the Nith, in the great chain of slate-rocks of the South of Scotland; one of which has long been celebrated for the foot-prints of Reptiles found on the sandstones of Corncockle Muir. The detail with which Mr. Harkness describes these deposits enables us to judge fully of their nature, and his observations have led me to a very different conclusion as to their origin, from that which he has himself formed. He starts by stating that the beds in question must be separated from the sandstone of Annan (east and west of the mouth of the Annan River), which he regards as a prolongation of the Triassic sandstone of the country around Carlisle, and in which there are no breccias made up of angular fragments.

Having thus disposed of the great tract of Red Sandstone of Annan, the Professor enumerates six other detached patches of sandstone, viz. the Corncockle Muir area on the upper part of the Annan, that near Moffat, another to the north, also in Annan Dale, one on the Capple Water, that on the Nith near Drumlanrig, and the still larger area around Dumfries, all of which the author considers to be the remaining portions of a once widely-spread deposit of sandstone, of which the greater part has been removed by denudation, and which he refers to the Permian period.

These various deposits have many features in common: they consist principally of red sandstones with their beds crossed by planes of false stratification ; interstratified with these sandstones, and usually towards their base, are sundry beds of coarse breccia, consisting of angular fragments of the identical rock against which the deposit rests,—that is, of slate where that is slate, and of trap at Drumlanrig where the breccia abuts against trap. These beds are everywhere at a considerable angle, varying from 12° to as much as 30°, and *in every instance they abut against a steep escarpment of rock, which, if stratified, dips in an opposite direction to the sandstones.*

It had been stated by previous observers that these various deposits of sandstone all dipped in the same direction ; which circumstance might have been explained by supposing the whole district to have been elevated from the east, giving a steep westerly dip to all the previously horizontal deposits of sandstone which lay in the bottoms of the valleys. But this conjecture is effectually disposed of by the more accurate observations of Professor Harkness, that the sandstones dip in different localities N.N.W., W.S.W., S., S.E., S.S.E., and N.; and he therefore suggests that a local depression or sinking of portions of the district in which the sandstones occur may have brought them all to their present anomalous position.

I do not recollect any other instance of a set of deposits, which only occupies one side of the valley in which it occurs, abutting at a high angle against the escarped edges of the rocks which, dipping away from the valley, bound it on that side ; and is altogether wanting on the smoother side of the valley, which is formed of beds dipping towards the middle of the valley : and every explanation must be defective which does not account for this peculiarity.

The facts so clearly stated by the author have suggested to me the idea that these deposits are portions of a talus of broken fragments which fell from the steep faces of the overhanging mountains into basins of water at their feet ; the materials of such a talus being necessarily composed of the overhanging rock ; the larger fragments are angular ; the smaller, having been disintegrated by rains and other atmospheric agencies, have attained the condition of sand or mud : the high inclinations of the beds of slaty rock in these localities have formed an important element in the cases before us, as their overhanging edges would supply such angular fragments in large quantities ; but on the opposite side of the valley, where the dip of the slates nearly coincides with the slope of the hill-sides, no such breaking off of fragments of rock would take place, and little or no talus would be formed, as the only materials carried down would be the finer matter washed down by rain and carried to the bottom of the valley.

The fallen materials constituting a talus at the foot of a cliff or steep escarpment arrange themselves in the open air at an angle of about 35° ; when they fall into still water, the angle is less ; and, if the water into which they fall has any motion, either from tides or a current, the angle will be materially less, depending on the velocity of motion of the water. The angles at which the breccias are found, and every other condition of the case before us, may thus be accounted for on the simplest principle, without calling in the aid of any violent operation of nature. The strongly marked false bedding of the sandstones is a proof of variable velocities in the waters in which they were formed, such as would occur in small lakes subject to increase from violent floods: the foot-prints have been referred to Chelonians, Lizards, and Batrachians; all more likely to be found on the banks of lakes than on the shores of the sea, and all proving the existence of land close by; it seems therefore probable that these small deposits were formed in lakes, and in that case the mountain-range across the south of Scotland must have had at the time nearly the same elevation above the sea as it has at present. This conclusion will leave us quite unable to fix on the geological age of the sandstones, which may have been formed at any period after that of the Mountain Limestone, the latest rock of which they contain any fragments. Professor Harkness considers them to be Permian.

This hypothesis is bold, and deserves attention as a legitimate deduction from the ordinary effects of existing causes, as now observable, though perhaps it would be better illustrated by the arrangement of artificial earth-works into distinct strata than by the depositions now formed under our sea- or lake-cliffs. The difficulty appears to be in accounting for the periodical fall of such large quantities of debris necessary to form the beds of breccia, and the alternation of such beds with those of ordinary sand. Angular lumps, or even patches, of breccia might be readily understood, but beds of considerable thickness continuous for many miles seem to imply an extent of fall and a simultaneity and regularity of such fall over a considerable lateral extension, not, I think, to be paralleled in nature. The wearing action in lakes must necessarily be less than in the sea, and the presence therefore of beds of breccia may fairly be regarded a good argument for considering these formations to be lacustrine.

An Essay of Professor Harkness on the Geology of Dingle Territory may be noticed here, as affording a striking illustration of the folding or convolutions of strata. It is unnecessary to follow the section throughout; nor is it necessary for the present purpose to discuss the question of the precise age of these Silurian strata: it is sufficient to state that Professor Harkness considers it impossible to assume that the two Silurian zones seen in the section, containing the same fossils and mineralogically the same, are successive deposits in one vast unbroken series,—a supposition which would have placed 12,000 feet of unfossiliferous strata between two fossiliferous deposits having the same organic characters; and he ascribes this intercalation of the supposed Devonian strata between the two Silurian deposits to the folding back of the strata, the axis of each of the great curves or convolutions having been thrown over to the north, and thus induced a southern dip throughout the whole mass. Another paper on the cleavage of the Devonians of the south-west of Ireland has been also published by Professor Harkness and Dr. Blyth in the Edinburgh New Philosophical Journal, and thus commented upon by Mr. Sharpe. The authors give some interesting details on the cleavage of the rocks of Valentia Island and the neighbouring parts of Cork and Kerry, and show, from an analysis of the slate, that the cleavage is most complete in those rocks which contain the most alumina, and that the specific gravity is greatest in the most slaty beds. They state that all their observations on slaty rocks seem to confirm my deductions that "there has been a compression of this mass in a direction everywhere perpendicular to the planes of cleavage, and an expansion of this mass along the planes of cleavage, in the direction of a line at right angles to the line of incidence of the planes of bedding and cleavage, or in other words, in the direction of the dip of the cleavage."—*Edinburgh New Philosophical Journal*, 1855.

The next paper that I shall notice is that by Mr. J. C. Moore on the Silurian rocks of Wigtownshire, in which he points out the curious arrangement of the rocks which form the peninsula between the Mull of Galloway and Corswall Point, and discusses the question of the relative positions of the graptolitic schists of Wigtownshire and the coarse conglomerate and limestones of Ayrshire. The preceding paper of Professor Harkness has already brought under notice the folded character of the Silurian strata in Dumfriesshire and Roxburghshire, and in this paper it is still more strikingly illustrated both in description and in the illustrative sections, the strata having been bent into a series of anticlinal and synclinal folds, the crown of the anticlinal in some cases being still preserved. As this folded condition of the strata can be observed for a distance of 30 miles, and as in the distance of 5 miles from the granite of Dunman to the Mull of Galloway fifteen such folds occur, it may be considered a very striking and magnificent example of this description of phænomena. In most cases the folds are thrown over to the north, so as to produce a short and a long leg to the curve, the strata of the short leg, to the north of the axis, being nearly vertical, whilst the strata to the south of the axis slope comparatively gently to the south. This arrangement is however sometimes reversed, as indeed it might have been expected would be the case, unless the direction of pressure had remained invariable. In the sections two masses of granite and syenite are represented as intruded amongst the sedimentary rocks, and the folds of the strata north of the granite are represented as thrown over to the north, whilst those south of the syenite are thrown over to the south, the strata between the two appearing rather ambiguous in their indications. The explanation of the folding of strata must still be classed amongst the only partially solved problems of geology. In the present example, as in the first of Mr. Moore's sections, we have two masses of intruded rock occupying a space of less than 4 miles, and a section of 26 miles of contorted strata in relation to them; and it scarcely seems possible, as observed by Mr. Moore, to consider the intruded masses as a sufficient proximate cause for the effect produced, though they may be reasonably considered indications of a powerful internal force, which, after producing a modified condition in the superjacent shale, caused a rupture or breach of continuity, and allowed the subjacent plutonic rocks to be pushed through them; and such appears to be Mr. Moore's opinion, as he considers the intrusion to have been subsequent to the folding of the strata, and to have even modified its usual E.N.E. strike. The next object of Mr. Moore is to determine the relative age of the graptolitic schists of Wigtownshire, as regards the conglomerate beds observed in the Loch Ryan Section, and at Corswall Point, &c. In Professor Harkness's paper the position of certain graptolitic and anthracitic beds associated together was shown to be above other fossiliferous schists also containing graptolites which lie close to the base of the Silurians; the object of this paper is to show that the equivalents of these graptolitic beds or the graptolitic schists of Wigtownshire are really geologically below certain conglomerate beds, though apparently stratigraphically above them. After a careful examination, Mr. Moore concludes, that the folds of the Silurian strata have thrown them over and caused them to appear as if deposited upon the conglomerate beds and limestone of the south of Ayr, which he considers the equivalent of the Wrae limestone and its associated conglomerates. The latter, Professor Nicol has shown to be superior to the graptolitic schists, and their apparently contradictory position in Wigtownshire and Ayrshire Mr. Moore ascribes to one of those great inversions or flexures so remarkable in the Ardennes, Eifel, and Appalachian Alps.

Another paper on Scotch geology was contributed by Professor Nicol, who describes the results of his careful examination of the Red Sandstones and Quartzites of the north-west of Scotland, over a district extending in a N.N.E. and S.S.W. direction, from Cape Wrath and Durness to Sleat, the southern portion of the Isle of Skye, containing an area of 100 miles in length by a breadth of from 15 to 30 miles. The immense difficulties which must ever attend the examination of so wild a district, independent of its magnitude, are fully recognized by Professor Nicol, and we must remember, as explanatory of the possibility of effectually examining it in a short time, that he had before gone over much of it with Sir R. Murchison, and that he had had before him the results of the labours of MacCulloch, Sedgwick, Murchison, and others. One of the most remarkable features in this paper is the recognition of two bands of gneiss, the one below, both as respects its position and the dip of its beds, the series of sedimentary rocks described, and the other apparently above them, as shown by the dip of the strata. In the Loch Broom, southern section, the lower gneiss appears underlying the Red Sandstone, and the series is lower gneiss in vertical beds, sandstone in very gently sloping beds, quartzite resting unconformably at a higher dip on the sandstone, a bed of porphyry or serpentine, upper gneiss, dipping at an angle of 23°, or nearly parallel to those of the quartzite. In all the other sections a siliceous limestone occurs between the quartzite and the upper gneiss, being in stratification conformable to both. The maximum thickness of the Red Sandstone with its conglomerates is considered to be about 3000 feet, thinning off to the eastward, and that of the quartzite, with its siliceous limestone, about 500 feet. The upper gneiss is represented as sometimes different in character from the lower, occurring in thin beds, often curved and twisted, and when near the porphyry, fine-grained, almost compact and composed chiefly of quartz with a little felspar and minute scales of mica. This gneiss indeed is supposed to be a rock metamorphosed *in situ*, and the metamorphic action is presumed to have extended downwards to the argillaceous beds of the quartzite series. In touching upon the subject of metamorphism, we may perhaps assume that a true gneiss in which crystallization is perfect, and where the difference between it and granite is little more than the laminated or bedded structure which it exhibits, must be looked upon, if metamorphic at all, as the most perfect form of a metamorphic rock, but in the rock here described there is little approach to that type; the great difficulty, however, must ever be to account for a metamorphism in a rock quietly resting upon others, in which the evidence of such process is at least very feeble. Every day, however, is bringing such cases before us, and, though the difficulty cannot be considered overcome, we must receive the facts without hesitation, though we may be unable to account for them. In the limestone some obscure fossils have been discovered, one supposed to be a Euomphalus, and another a Lithodendron; notwithstanding the uncertainty which hangs over their determination, Professor Nicol thinks he has reason to consider the limestone beds containing them and the quartzite, to belong to the carboniferous epoch, and the underlying sandstones to the Devonian. In this conclusion, he is opposed to Sir Roderick Murchison, who considers these rocks Silurian; nor does Professor Nicol evade the difficulty consequent on the position of the gneiss in the central region of Ross and Sutherland, which passes under the Old Red Sandstone of Ross-shire and Caithness, but states his conviction that there are several deposits of Red Sandstone and conglomerates of different ages; and, further, that he does not consider that any proof has as yet been given of the identity of the underlying gneiss of the east coast with the overlying gneiss of the west, but rather perhaps that the lower gneiss of the west may be the representative of the eastern gneiss, having been pushed up amongst deposits of different ages. Though no one can doubt the accuracy of Professor Nicol's fieldwork, and though, I may add, there is no impossibility in his deduction from it, even his own words justify me in saying that the subject still requires further examination. The references to glacial action, as exhibited in local accumulations of drift, in highly polished surfaces of rock, and in detached "perched blocks," are interesting as extending our knowledge of such facts, but are hardly sufficient to prove any considerable elevation of the Highlands above their present level, followed by a subsidence and then by a later partial elevation. I cannot but think that more caution is necessary in dealing with such great phænomena.

The great work of Guido and Fridolin Sandberger, on the Rhenish Provinces of Nassau, has now been brought to a close by the publication of the last part, which, whilst it completes the natural-history portion of the work, contains also the Geological relations of the strata examined and described. Without going into a minute detail of the fossils described in this Second Part, it may be stated that in the *Echinodermata* Messrs. Sandberger have added 1 species to the Asteriadæ, to the Echinidæ 2 species of the still living genus *Cidaris*, to the Crinoidea, of the characteristic features of whose organization a very clear and detailed description is given, 2 genera, *Myrtillocrinus* and *Stylocrinus*, and 6 species, the second however in the genus *Stylocrinus* being founded on a species separated from the genus *Platycrinus*, the species here described being a *Platycrinus* of Goldfuss. I have singled out this class as one perhaps of the highest interest, and so large an addition of species in so limited a space affords another example of the extraordinary increase in our knowledge of the fauna of remote epochs, which every day is now affording us. In the five sections into which the authors divide the Rhenish Formations of Nassau,—namely (beginning from below), 1. Spirifer-sandstone, 2. Orthoceratite-schist, 3. Stringocephalus-limestone, 4. Cypridina-slate, 5. Posidonomya-schist,—his tables contain, of Fishes, 2 species, 1 belonging to each of the two more ancient sections; Crustacea 26, of which 2 are common to the two older sections, 2 to the second and fourth, and 1 to the first, second, and fourth; Annulosa 8, of which, one only belongs to the second, and the other seven to the third section; of Mollusca in the order *Cephalophoda*, 151, of which 1 species of Goniatite, *Goniatites retrorsus*, is common to sections three and four: 1 species of Orthoceratites, *Orthoceras triangulare*, is common to one and two; *Orthoceras planiseptatum*, to one, two, and four; 2 species, *Orthoceras lineare*, *O. arcuatellum*, to three and four; and 1, *O. regulare* to two and four. Of the Gasteropoda, 80, of which no single species is represented as common to two divisions of the shales, and about 80 per cent. of the whole belong to the third section. Of the Pteropoda 12, of the Pelekypoda 73, of which 3 are common to the first and second sections, the order preponderating as to number in the first section. Of the Brachiopoda 57, of which 3 species are common to the first and third sections. Of Bryozoa 7, being all in the third section. Of the Echinodermata 17, no species being common to two sections. Of Polypi 18, of which 1 species is common to the first and second, and 1 to the second and third. In Plants, 3 species belonging to 3 different genera of vascular plants were found in the first section, and 2 species also of different genera in the second section, not even a single genus of the six enumerated being common to two sections. Of vascular plants, the Acotyledones are represented by a single species of 8 distinct genera, and the Dicotyledones by a single species of 3 distinct genera, all occurring in the fifth section. I have dwelt on this portion of the statistics of the works of Sandberger, because, whilst it exhibits very strongly the individuality of each of the five sections, it also affords some examples of the passage of a species from a low zone to one higher in the series, though apparently lost in the intervening zone. Examples of this kind are every day increasing and call for the most careful investigation; for, though it is easy to adopt the notion of species living over, as it were, some catastrophe which had destroyed others, it is not so easy to explain why such species should have disappeared and then reappeared, the strata not even admitting the explanation in this case by a recurrence of the same physical conditions. Investigation proves the fact, and I imagine, as no one will probably advance the theory of a second creation of the same species, that the appearance of the same species in two formations geologically separated in time must be taken as a strong argument for believing that, though locally destroyed, the species had still continued to exist in other regions, the harmony of which had not been similarly disturbed, and hence that the unity of the creation has never been entirely broken up. The importance of the fossil evidence may be understood from the summary of the species described given by the author; thus, combining the Spirifer-sandstone and the Orthoceratite-schist into one group—the lower, the Stringocephalus-limestone and Cypridina-schist into another—the middle group, and taking the Posidonomya-schist as the upper group, 107 species occur in the lower group, 225 in the middle group, and 24 in the upper, in addition to 8 species which are common to the lower and middle groups. In addition to the very able discussion of the fossil evidence, there are many very interesting particulars in the work: such, for example, as the careful discrimination of the physical conditions of the deposits from the general relations of the fossils and their natural habitats, and the chemical comparison of metamorphosed with unmetamorphosed nodes, a species of comparison I have indeed at a former period suggested, in reference to the general question of metamorphism, but which is here made subservient to the recognition of the former metamorphosed strata in the present unmetamorphosed. As regards the geological comparison of the Nassau deposits with those of other countries, I cannot deny myself the pleasure of preserving the observations of Mr. D. Sharpe. He observes:—

The completion of the work of the two distinguished brothers, Dr. Guido and Dr. Fridolin Sandberger, on the Devonian fossils of Nassau*, will be hailed with satisfaction by all palæontologists: the accurate descriptions and figures which it gives us of the species of organic remains of Nassau, with distinct reference to the beds in which they are found, will prove of great help to us in unravelling the still only half-solved problem of the order of geological succession of the various deposits constituting the Devonian system. As the principal portions of the palæontological part of the work were published in past years and have already received due mention from Mr. Hamilton, I shall confine myself to an examination of the appendix which contains the authors' comparison of the palæozoic formations of the Rhenish Provinces with those of other countries, in which we are naturally most interested, more especially in regard to their remarks on Devonshire, and on the analogous formations of Belgium and the

* Die Versteinerungen des Rheinischen Schichtensystems in Nassau. 4to. Wiesbaden, 1850 to 1856.

Boulonnais, which from their proximity are likely to throw most light on those of our own country.

The formations of Nassau are classed as follows:—

1. *Posidonomya-shales,* characterized by *Posidonomya acuticosta* and containing also eleven species of plants, some of which are found in the coal-measures, of these *Calamites transitionis* and *Stigmaria ficoides* deserve especial mention. The authors regard this bed as the base of the coal-measures and as superior to the mountain-limestone; they know of no equivalent to it in France or Belgium, but consider it identical with the shales containing *Posidonomya* near Barnstaple in North Devon, and Launceston in Cornwall; the *Posidonia Becheri, P. tuberculata,* and *P. lateralis* of Sowerby and Phillips being considered varieties of *Posidonomya acuticosta,* Sandb.; in this last view, I fully coincide, as I believe that the varieties of form which led to an attempt to form these species are due to distortion, but I do not think that the earliest name, *P. Becheri,* should be abandoned.

2. *Cypridina-shale* characterized by an abundance of the little *Cypridina serrato-striata*: these beds also contain many species of *Goniatites* and *Orthoceras,* the *Clymenia subnautilina,* and remains of fishes, of which some may perhaps belong to the genus *Holoptychius*: ten of the species of this formation are also found in the Eifel-limestone. Its supposed equivalents are the Clymenien-kalk of Thuringia, Saxony, &c.; the Cucullæa-sandstone of Marwood, North Devon; the Petherwin-beds of Cornwall, and the shales containing *Cypridina* above the limestone of Chimay in Belgium, &c.

3. *Stringocephalus-limestone,* in which 171 species of fossils have been found, of which certain species of corals and *Stringocephalus Burtini* (under the new name of *S. hians*) are most characteristic; 6 of these species occur in the mountain-limestone, 1 in the Orthoceras-slate, 2 in the Spirifer-sandstone, and 3 in the Silurian system. The species common to this formation and to the Eifel-limestones of Paffrath, Bensberg, and the Eifel, and to the limestones of Torquay and Plymouth, are so numerous as to connect these deposits together most satisfactorily: the authors also connect with it the limestone of Chimay in Belgium, which contains 18 species in common with it, among which is the *Stringocephalus*; though other species found at Chimay might induce us to place that limestone somewhat higher in the series.

4. *Orthoceras-slates* of Wissenbach, &c., a blue roofing-slate, with some beds of dark bituminous limestone, in which the shells are usually in iron pyrites and sometimes in lead ore; it abounds in species of *Orthoceras* and *Goniatites,* of the former of which genera there are two Silurian species. This bed has not been recognized out of Germany.

5. *Spirifer-sandstone,* usually a fine sandstone or sandy slate, with some rare beds of clay-slate, indicating, as there are no conglomerates, a deposit in a deep sea far from the coast; 57 species of fossils are enumerated, of which *Spirifer macropterus* and *S. auriculatus, Chonetes sarcinulata,* and *Ptilodictyon problematicum* are considered

characteristic ; thin layers of anthracite and numerous impressions of algæ are found in some localities. Seven species of this sandstone are also found in the Silurian system. The authors consider the following deposits to be equivalent to the Spirifer-sandstone of the Rhine :—the sandstone of Meadsfoot lying below the Torquay-limestone and containing *Pleurodictyon, Spirifer macropterus*, &c., the sandstones of Couvin and Houffalize in Belgium, those below the limestones of the Eifel, and of Siegen in Westphalia. This is probably equivalent to M. Dumont's *Système Coblentzien.*

The greater part of Nassau is covered by the *Spirifer-sandstone* ; the more modern deposits only occur in two districts, in both of which they are associated with various crystalline rocks, and are thrown about in such confusion that nowhere is a consecutive sequence of deposits to be seen, and their relative ages are derived from comparing them with similar beds in less disturbed districts of the Rhenish Provinces. Owing to this circumstance it is impossible to know how many beds may be missing in Nassau : the authors mention the following, as required to complete the series of formations, viz.—1. The *Mountain-limestone,* which they suppose to be wanting below the *Posidonomya-slate* ; the *Ferques-limestone,* with *Spirifer calcaratus,* &c. placed below the *mountain-limestone* and above the *Cypridina-slate* ; the *Calceola-slates* below the *Eifel-limestone.* With these exceptions, the authors appear to think that the Nassau series contains equivalents of all the deposits found elsewhere between the coal-measures and the Silurian system.

Upon these conclusions I must remark that I do not concur with the authors in placing their *Posidonomya-shales* in the coal-measures, and above the mountain-limestone. If we only knew this bed as occurring below the culm-measures in Devonshire and Cornwall, we might hesitate in differing from two excellent palæontologists who had devoted so much labour to this subject ; but the position of the *Posidonomya-shale* admits of no doubt in the county of Northumberland, where it is to be seen on the coast near Budle, below the lowest part of the mountain-limestone, crowded with the same species of *Posidonomya* as are found in Devon, Cornwall, and Nassau. The true place of this bed is there seen to be at the base of the Carboniferous series. I cannot either agree with these authors in considering the Marwood and Petherwin beds as equivalents of the *Cypridina-slates.* At p. 516 they quote *Cypridina serrato-striata,* as found at S. Petherwin, without stating their authority, which, as I believe they never visited Cornwall, has possibly been derived from some mislabelled specimen. I cannot learn that any one has ever found that little Crustacean at Petherwin, or in the corresponding beds of the Pilton group in North Devon ; but Mr. Godwin-Austen informs me that he saw it, in company with Mr. F. Rœmer, in beds which he considers higher in the series.

On the other hand, nothing is better established than the identity of the Petherwin beds with those of Ferques in the Boulonnais, which are overlaid, as has been shown by Mr. Godwin-Austen*, by yellow

* Journ. Geol. Soc. vol. ix. p. 239.

sandstones containing the same species of *Cucullæa* as that found at Marwood.

The other identifications of the authors of the *Stringocephalus-limestone* with the Eifel-limestone and the limestones of Plymouth and Torquay, and of their *Spirifer-sandstone* with the sandstone of Meadfoot, Torbay, are without doubt correct. But I can hardly class the limestone of Chimay with that of the Eifel without farther evidence: and I incline to believe that we shall ultimately find the Devonian series to include many more beds than are contemplated in the table given in this work, and that we shall only appreciate the difficulty of placing these various beds in a consistent order when we have convinced ourselves that no district yet examined in Europe contains all the beds of the series. The enormous development of the Devonian series in the State of New York confirms the propriety of this conclusion, which indeed is only a reasonable deduction from natural facts; as no one deposit could be assumed to have extended over the whole surface of the earth.

I cannot take leave of this valuable work without expressing my dissent to the creation of new specific names for species long since described by others. From a passage in the Introduction, the authors seem to consider that they may change any name which does not express any of the characteristic points of the species. It is a duty to protest against such a doctrine, which, if generally carried out, would throw Natural History back into a hopeless chaos. The evil is aggravated in the present instance by the almost entire omission of synonyms in the index of species: so that a student can only ascertain whether a species long since named is described in the work by looking through the several lists of synonyms of the species described in the text.

In respect to the last remark of Mr. Sharpe, I have thought it right to preserve it as expressing his opinion on a point of great importance. Without doubt the wanton change of a name long since proposed is in every respect wrong; but at the same time the preservation of names which convey a wrong idea, and force every student of nature to go through the process of disabusing his mind of that idea before he can reason on the facts before him, may assuredly be carried too far. The remarks of the Sandbergers especially apply to this class of names, as they observe that no one will probably dispute the propriety of adhering to the maxim of Linnæus, that those names which indicate the essential characteristics in the habitat of the animal are the best when we are naming species previously unknown; but they have gone further, by here and there applying this excellent maxim to species which have before received names expressive of no real (I may even say too often a wrong) meaning, such as *primævus*, *primordialis*, *incertus*, *dubius*, *anceps*, *ambiguus*, *neglectus*, *affinis*, *similis*, &c.; adding, however, that in cases where their materials were insufficient for the foundation of a new name on sound principles, they have left the old name undisturbed. Let me add also that Messrs. Sandberger have carefully preserved to the first discoverers of species the honour due to them by still attaching their names to them when the generic names only have been changed, as for example *Stylocrinus scaber* (Goldfuss) replaces *Platycrinus scaber* (Goldfuss),—*Retzia ferita* (Von Buch), *Terebratula ferita* (Von Buch),—*Retzia lepida* (Goldfuss), *Terebratula lepida* (Goldfuss), &c.; and, on the whole, I think the only blame to be laid to the charge of these most able men is that they have not spared the reader the trouble of reading the synonyms in the descriptions of species by enabling him to use the index alone.

The next paper I purpose bringing under your notice, is that of Dr. Wright, on the Palæontology and Stratigraphical relation of the Sands hitherto called Sands of the Inferior Oolite; the object of the author being to demonstrate that these sands ought, from their fossil relations, to be attached to the lias, and not to the oolitic series of deposits. Lithologically, the sandstones are represented as very fine, brown and yellow, calcareous sands, often micaceous, and containing within the lower part concretionary masses of coarse sandstone; and in the upper, layers of siliceo-calcareous sandstone, whilst the lowest beds of all become blue and marly, and pass insensibly into the clay of the upper lias.

As the sands themselves are not fossiliferous, though the nodules sometimes lying near their base often contain organic remains, Dr. Wright has made "a bed of coarse brown marly limestone, full of small, dark, ferruginous grains of hydrate of iron, imparting an iron-shot aspect to this rock" the testing stratum for determining the true position of the supposed oolitic sands. This bed, rich in Ammonites, Nautili, and Belemnites, and hence called the "Ammonite and Belemnite Bed" by the Rev. Mr. Brodie, and the "Cephalopoda Bed" by Dr. Wright, is compared by the latter with the hard stone-marl of Germany described by Dr. Oppel of Stuttgart, with the sandstone and supraliasic grit of the Moselle described by M. Torquem, and with the beds described as upper lias by many other foreign and British geologists; inferring that, if this identity be admitted, and the Cephalopoda-bed be considered upper lias, the sands below it must necessarily be separated from the oolitic, and classed with the liasic strata.

This question manifestly depends, first, on the accurate determination of the organic remains on which it is made to rest. Dr. Wright seems to have been careful in his investigations, and to have adopted every precaution to guard against mistakes; and secondly, on the correct determination of the position of the foreign beds with which Dr. Wright places his Cephalopoda bed in comparison. In his table, showing the stratigraphical distribution of the fossils enumerated in his several lists, occurs *Ammonites jurensis* which is the cephalopod adopted by Oppel as characteristic of the upper zone of his upper lias; Dr. Oppel, however, points out the great difference in opinion of many preceding writers, as to the true position of this zone; many having carried it up to the lower boundary of the oolites, or even to the zone characterized by the *Posidonomya Bronni*, stating, however, that his own opinion concurs with that of Dr. Wright. When it is stated that of the eighteen species of cephalopodous molluscs, seventeen occur in the French bed to which the comparison is extended, ten in the Belgian, and thirteen in the German, there can be little doubt of the identity of the several beds; and as regards the position of those beds, I may observe, that, whilst eight species descend to the upper lias clay, or to a bed below the disputed sands, not one species rises to the inferior oolite, as recognized by Wright and Oppel either in England or on the Continent, though the said inferior oolite contains no less than fourteen species of Cephalopoda in England, twelve of which are also found in the corresponding bed in France, though nearly absent from the beds of Belgium and Germany. If thus the upper Cephalopoda-bed be attached to the oolites, the demarcation-line must be carried down so far as to include even the upper lias clay in the bed below the doubtful sands. Judging, then, from the present evidence, I cannot but think there is much reason for attaching this section of the strata in question to the liasic series.

Having referred to the authority of Dr. Albert Oppel in my remarks on the paper of Dr. Wright, I will now briefly notice the very important work of that author on the Jura-Formation. Geology has now arrived at a point where the "correlation of the minuter divisions of the deposits of different countries necessarily becomes the object of geologists." On the surface of the earth, as it now is, we know that the deposit we see forming at one place can afford us no positive information as to that which simultaneously may be forming at another and distant place: each requires to be studied by itself; and, were it not that we know as a fact the contemporaneity of their formation, we should often find great difficulty in proving it. The same comparison must be made between the separate deposits of former epochs, though the difficulty is so much the greater, as the positive knowledge which we possess as to the time of deposition of recent strata is here totally wanting, and is the thing to be proved. The term 'correlation,' and the process it expresses, have both been rendered familiar to us by the continued labours of Mr. Prestwich on the Tertiaries, and others have followed in the same line of inquiry, such as Murchison and Barrande on the Silurians, the Sandbergers on the Devonians, and Dr. Oppel on the Jura Formation. In this work he divides this great and peculiarly interesting formation into three great divisions:—1. the lower jura, or lias; 2. the middle jura; 3. the upper jura. He then proceeds to the consideration of the lower jura or lias, and subdivides it also into three sections, namely,—

	Germany.	France.	England.
1.	Unterer Lias.	Sinémurien.	Lower Lias.
2.	Mittlerer Lias.	Liasien.	Marlstone, or Middle Lias.
3.	Oberer Lias.	Toarcien.	Upper Lias.

The Middle Jura is also divided into three stages or sections thus:—

	Germany.	France.	England.
1.	Unter-Oolith.	Bajocien.	Inferior Oolite.
2.	Bath-Gruppe.	Bathonien.	Bath Oolite.
3.	Kelloway-Gruppe.	Callovien.	Kelloway Rock.

As the third part of the work has not yet been published, the subdivision of the Oberer Jura cannot be at present stated. This threefold division is ingenious and practically useful, though, of course, the result of such arrangements must always be a tendency to force the natural grouping into a conformity with the artificial. In the preface Dr. Oppel pays a just tribute of respect to the memory of William Smith, who, he observes, first laid the foundation, in the years 1815–16, for a correct classification of the Jura Formation, by his work entitled, 'Strata Identified by Organized Fossils,' which being followed by the Outlines of Conybeare and Phillips, at a time when little had been done in this way in France and Germany, spread the English names over the Continent, where they were freely adopted, still preserving their identity in Germany; whilst in France they have been formed into French names more consistent with the genius of the French language.

In proceeding to the further subdivision of the several sections of the lias, Dr. Oppel carries out the views of Von Buch, and founds his subsections on the predominance of individual fossils which appear to characterize each subsection. In the lower lias, therefore, he distinguishes no less than eight such subsections, the lowest being the celebrated Bone-bed, by which it may be said the Jura Formation and the Triasic appear to be connected, if, indeed, as many believe, the bone-bed should not rather be entirely allotted to the Triasic. The other seven subsections are thus named from below upwards:—

1. Bed, bank, or zone of Ammonites planorbis.
2. Bed of Ammonites angulatus.
3. Bed of —— Bucklandi.
4. Bed of Pentacrinus tuberculatus.
5. Bed of Ammonites obtusus.
6. Bed of —— oxynotus.
7. Bed of —— raricostatus.

Now, if we observe that the bone-bed is separated from the bed or zone of *Pentacrinus tuberculatus*, which is the rich depositary of Ichthyosauri and Plesiosauri by three other beds, and recollect that the bone-bed has its own characteristic assemblage of Saurians and other animals, totally distinct from those of the Pentacrinus-bed, and of which some species are common to the Muschelkalk,—it seems more reasonable to connect it with the trias than with the lias. On this question Oppel thus observes:—"The remains of Vertebrata in the bone-beds harmonize with those of the trias, and this not alone in respect to genera, but also as regards species, several of which have been found by Plieninger in the bone-bed of the Muschelkalk of Wurtemberg; namely, *Gyrolepis Alberti*, *G. tenuistratus*, *Saurichthys acuminatus*, *Sphærodus minimus*. At the same time some species of Vertebrata occur in the lias bone-bed which do not appear in the lower or triasic strata, such as the teeth of *Hybodus*, which occur in the middle region of the lower lias of Lyme Regis, whilst in foreign localities some of the remains of Saurians occur in the same hand-specimens with *Ammonites planorbis*, so that there is a certain balance of authority on the subject as regards the Vertebrata; but in respect to the Mollusca, Dr. Oppel observes, that they harmonize best, as shown by Escher von der Linth, with the upper St. Cassian beds, and he thus concludes:—If it cannot be decided with certainty that the bones of Vertebrata found in the bone-bed were originally buried in a deposit of the Keuper, it must at least be admitted that the animals themselves had lived at that period;" and I may add, only specializing the further remarks of Oppel, that it would seem impossible to account for the occurrence of such saurian and other remains in the bone-beds of England and Ireland by supposing them to have been removed from a previously existing triasic formation, and then deposited in a liasic formation, as no trace of the Muschelkalk bone-bed has been hitherto found in England and Ireland, unless the bone-bed itself be the equivalent of the Muschelkalk, as I ventured to suggest some years ago, in my Report on Londonderry.

Der Mittlere Lias, Liasien, or Middle Lias, as representatives of which in England Dr. Oppel adduces Upper Lias Marls of De la Beche, the iron-stone and marlstone of the upper portion of the Lower Lias shales of Phillips, he divides into five zones, characterized as the zone or bed of *A. spinatus*, that of *A. margaritatus*, which zone he subdivides into an upper and a lower, that of *A. Davœi*, Sow., a fossil which Oppel himself observed at Charmouth, Dorsetshire; that of *A. Ibex*; and that of *A. Jamesoni*; to which it is suggested by Oppel that another, *A. armatus*, might be added. Der Obere Lias, Toarcien, or Upper Lias, as representatives of which are quoted the Alum-shale, the lower portion of the inferior oolite of De la Beche, the Harley sandstone of Conybeare and Phillips, the Upper Lias of Phillips and of Murchison, Oppel divides into two great zones, characterized as the zone or bed of *Ammonites Jurensis*, and that of the *Posidonomya Bronni*. It is not my intention to follow the author into his subdivision of the Unter-oolith, Bajocien, or Inferior Oolite, being the lower of the three sections of Der Mittlere Jura, which is effected upon the same principle, namely, that of adopting some fossil, generally an Ammonite, as characteristic of each of the five subsections into which he divides it. This principle implies that the actual range in time of each of these fossils has been accurately determined; but surely such a determination cannot be considered final or satisfactory until the range in space has also been determined; and further, even supposing the centre of the vertical sections (representing time) through which each of these fossils extends in different countries be actually on the same geological level with each other, can it be expected that the lower and upper limits should also be so, in all countries? I say this, because I fear that, however natural such a system of subdivision may appear, it must at present be considered only artificial, and prove efficient only for those countries in which the boundaries of the spaces occupied by the characteristic fossils of the supposed adjacent zones prove to be coincident.

Dr. Oppel appears to have examined and compared the fossils with very great care, and has pointed out those which pass beyond the limits of any one zone into the region of another, so that he has done his best to enable every geologist to discuss the subject for himself, and form his own conclusions from the data set before him.

As the French names of D'Orbigny used by Oppel are not, perhaps, quite familiar to every one, I will give their explanation below, from above downwards :—

Portlandien,—Portland Rock.
Kimmeridgien,—Kimmeridge Clay.
Corallien,—Coral Rag.
Oxfordien,—Oxford Clay.
Callovien,—Kelloway Rock.
Bathonien,—Bath Oolite.
Bajocien,—Lower Oolite, from Bajocea or Bayeux in Calvados.
Toarcien,—Upper Lias, from Toarsium, or Thouars.
Liasien,—Middle Lias, or Marlstone.
Sinémurien,—Lower Lias, from Sinemurium, or Semur.

In respect to this nomenclature, I may observe, that in common with every other, it possesses the disadvantages necessarily attendant upon every attempt at the classification of still imperfect materials. Eight of the names are derived from local deposits, and are, therefore, useful as indications of supposed typical localities ; but this advantage has the counteracting disadvantage of leading observers to anticipate a much greater identity in the faunæ of different localities than our present knowledge will allow us to expect: one is founded on the predominance of a special order of fossils, but here again the geologist would be led astray, were he to seek for or expect to find a similar fauna at each equivalent epoch in the formations of every portion of the globe. The great question really is, what deposits were in course of formation in France or Germany, or in any other portion of the world, at the moment when the Oxford Clay and the Kimmeridge Clay were being deposited in England, or when corals were abounding on its shores? Such names, therefore, should be considered as merely significant of the port, as it were, from which the geologist intends to commence his voyage of discovery.

Perhaps no epoch in the history of the world is so deserving of consideration and reflection as that in which the Tertiary strata have been deposited, as the relics of species imbedded in them, which have continued to exist up to our own time, must at least dispel from our minds the idea that any vast destructive agency destined to annihilate one creation as a preparation for another could have operated on the fauna within this period. The vast extension of these formations, once considered merely local deposits, is also a fact deserving of attention, though in itself so natural. The research into the phænomena of this class of deposits has for some years been popular amongst us, as might have been expected when we consider how much the correct appreciation of everything connected with the Tertiary formations has been promoted by the labours of Sir C. Lyell. During the present session we have had a paper from Mr. Godwin-Austen on the Newer Tertiary Deposits of the Sussex Coast, in which the author follows up a class of inquiry he had before entered upon in respect to the coasts of Cornwall, Devon, the Channel Islands, and the Cotentin, namely the determination of a series of oscillations in the level of the land, of comparatively recent date. As preparatory to the consideration of this highly interesting question, Mr. Austen first notices the condition of the English and French coasts, and points out that the irregular wear consequent here, as everywhere, on the unequal resisting power of the rocks exposed to the action of the sea, has produced the various bays or indentations, such for example as Weymouth Bay and Yarmouth Bay, though the wear was probably accelerated or retarded by either a depression or an elevation of the coast, tending to remove from the action of the sea a more easily disintegrated stratum, or to bring up a less destructible one. Such wear as this depends upon the *impulsive* action of the waves, and wherever it can be traced inland, proves that the sea must at one time have had access to the inland indentations, just as it now has to the coast-bay, a remarkable instance of which I have pointed out in the north of Ireland, where such indentations occur in a chalk escarpment now 200 feet above the level of the sea, the inland bays thus formed having been filled up with the mud of the pliocene epoch before the period of that final elevation which abstracted them from the action of the sea. The same is the case in respect to the coast described by Mr. Austen; the sea is still making an impression upon the softer portion of the rocks, and nothing can be more variable in destructibility than the chalk; but it is also threatening to break through the barriers which keep it from storming the bays or indentations which were formed by the former action of its waves.

If, instead of prospectively regarding the results of this continued action, we were to trace it backwards, there would be no great difficulty in mentally tracing the cliffs as they receded from the present inner land on both sides until they met and barred across the channel, as supposed by Mr. Austen, without even the intervention of any material elevation or subsidence. On such a supposition, the action of the waves of the western ocean on the one side, and of those of the northern on the other, must have rapidly advanced the work of destruction, until the formation of the channel by the final rupture of the barrier, when the action would still continue, but be varied in its direction. Taking up now the elements upon which Mr. Austen founds his theory of change of level,—he first points out that the summit-levels of the hills extending from Devonshire are capped by a detritus, the upper portion of which is characterized by rounded pebbles of primary rocks—white quartz, porphyry, and granite, and this fact alone necessarily implies that the tidal or transporting agency of the sea was then exercised at levels corresponding to the position of the pebbles, and before any portion of the chalk had been raised sufficiently to come within the sphere of its action, as no flint or chalk pebbles are raised with this detritus. Mr. Austen further assumes that the gravel was deposited before the surface had been intersected by its present deep combes and broad valleys, which is at least a reasonable supposition; as soon however as elevation had removed the crystalline rocks from the action of the sea, and brought *any portion* of the chalk within it, the gravel would assume a different character, and be composed of chalk and flint pebbles, capping the tertiary deposits which had been in progress of formation, and filling up some of the indentations which had been previously formed in the softer strata, and which had become the mouths of land-valleys. These gravels were again cut through by fluviatile action on further elevation, and the remains of elephants and other large mammalia brought into view; affording proofs, not only of the existence of dry land upon which such animals must have lived, but also of a vegetation suitable to their existence. Again, the beds of peat with timber trees which are seen at low water opposite the openings of these valleys are further indications of dry land, though, as Mr. Austen observes, these are not proofs of recent change, but simply of the removal of some barrier which had before shut out the sea from them.

Up to this point it will be observed that the phænomena would appear to be explicable on the theory of one continuous and gradual elevation, but Mr. Austen adduces other facts which indicate both elevations and depressions. The section of one of the docks at Portsmouth, taken from a paper by Colonel James, shows, for example, stumps of trees in place on the London Clay, and covered with a bed of mud and vegetable matter 2 feet thick, this again being covered by an estuary mud with shells, 4 feet thick, then by a bed of sand and shingle, and finally by the mud of the present estuary, the whole indicating a considerable amount of subsidence, following an elevation which had brought the London Clay to the surface and left it there for a time sufficiently long, first, to have prepared it for vegetable growth, and then to have permitted the development and growth of large trees. This section is the more remarkable, as three artesian borings have been made in the neighbourhood, forming a triangle, neither angle of which can be more than 1¼ mile from it, without discovering any trace of a land-surface. At the one made at Blockhouse Fort, a bed of oysters was found under a shingle deposit more than 60 feet thick, so that the surface of the London Clay appears to have shelved off from the position of the docks outward, the superficial deposits, including the "sand and shingle," having been much thinner there than at any of the artesian borings, so that upon elevation it must have been a bank, whilst its surface at the other points remained submerged.

Pagham Harbour affords another striking example of oscillation of the surface, as a silt-deposit with bands of *Cardium edule* and *Mactra solida* overlies an old terrestrial surface bearing trees which *are rooted* in the uppermost of a series of beds which the author considers must have been part of a marginal sea-zone. This latter conclusion, however, appears very doubtful, as it is by no means probable that such a growth of trees as is visible in this, the Portsmouth, and many other cases could have belonged to a sea-zone or margin; on the contrary, it is far more probable that these localities were then sheltered spots, secured from the sea-blast by an advanced line of coast.

It is unnecessary that I should follow Mr. Austen as he endeavours to trace out the several oscillations of the surface, by which perhaps a depression was produced here, and an elevation there, tending at one point to change a terrestrial surface into a marine bottom, and at another to place a marine bottom in the conditions of a terrestrial surface; and still further to distinguish from the effects of such changes the alterations produced either simultaneously, or before or after the last undulation, by the action of the waves; but I shall briefly notice some of the elements of the inquiry. I have before pointed out the distinction between the gravel of crystalline rocks and that of the chalk with its imbedded flints; in some cases the pebbles of the former occur in the latter, and this might reasonably have been expected on the mere supposition of depression, as the highest shingle would necessarily have been then exposed to the action of the waves and removed to lower levels; but Mr. Austen thinks it impossible to refer these pebbles either to the western rocks of England or to those of France, and states his belief that the *ancient coast-line* along which these pebbles had drifted was neither that of the west of England nor that of France, but was in fact connected with a mass of old rocks which constituted an eastern extension of the axis of the Channel area, now submerged; and I need scarcely add that a similar supposition has been advanced in explanation of certain climatal differences observable in the tertiary deposits, which, it is presumed, might have been the consequence of the sudden removal of a barrier which had before shut out the warm western waters from the regions previously occupied by the waters of the North Sea. That a barrier has been removed can scarcely be doubted; and that the removal of that barrier may have been assisted by a line of fracture, produced either by elevation or depression, is almost equally certain; but the pebbles of this shingle seem a slight basis for the assumption of the existence of a former mass of old rocks in this direction. One curious illustration of depression is derived from the form of the bottom of the Channel, which Mr. Austen represents as exhibiting "lines of troughs and an advancing platform indicative of an old coast-line;" but it is doubtful whether mud-deposits on a coast would retain on submergence this marked character, and it is equally probable that submarine currents would tend to produce and preserve a cliff-like character in the lower deposits. A more striking proof is derived from the mollusca in the Selsea deposits, which indicate, as Mr. Austen observes, by their habits, shallow water and marginal conditions, that the eastern extension of the Channel at that period may be represented by a line extending from the coast of Sussex to that of Normandy, and that the remaining portion of what is now the eastern end of the *English Channel was in the condition of dry land.* The evidence upon which the great changes which are shadowed forth in this paper depend must be studied in the paper itself. I will only further notice the theory of the brick-earth, which deserves attention, as Mr. Austen represents it as a subaërial deposit, produced by the washing of the land at a time when there was a much heavier rain-fall than at present; but, as such wash is at present first directed to the lines of watershed, and then by fluviatile action carried towards the sea, forming the deltas of rivers, it still seems necessary to explain the position of the red earth, as a rain-deposit, in the several sections given by Mr. Austen. The paper is one of great interest, on a subject of extreme difficulty, affording ample exercise both for the industry and the ingenuity of the author.

In my previous remarks I have pointed out, more especially in drawing attention to the distinction which Mr. Sharpe had so ably drawn between the ancient faunæ of the north and south of Europe, that at this epoch in geological science the great question is, not to establish an identity between the natural history of distant areas of the ancient surface of the earth, but rather to determine which of many much-varied faunæ and floræ were actually of contemporaneous origin. It is this change in the aspect of geological inquiry which has rendered the correlation of strata a task of such extreme difficulty as to have long exercised, as it will still exercise for many years, all the penetration and cautious inquiry of Mr. Prestwich, who seems specially fitted for a research which requires a combination of so much perseverance, so much patience, and so much ability, and which resembles in difficulty the unfolding and deciphering of some ancient papyrus scroll. In a former paper Mr. Prestwich had expressed his opinion that the Eocene strata of France, Belgium, and England were capable of subdivision, and that portions of each might be identified as contemporaneous formations; as, for example, the Sables Inférieurs of France, the Landenian and Lower Ypresian Systems of Belgium, and the Thanet Sands, Woolwich Series, and London Clay might be thus classed together as deposits of the earliest periods (in time) of the Eocene age. As the most remarkable development of these deposits occurs in England, Mr. Prestwich proposed for them the name of the "London Tertiary Group;" and I may remark in respect to this group, that the consequences which might be drawn from the great thickness of these deposits within the English area do not appear to have been fully considered. The ordinary thickness exceeds 300 feet, but at one point at Portsmouth it was found to be 600 feet, indicating therefore a great comparative depression of the subjacent bottom either before or during the deposition of this lower section of the Eocene strata. To this lower section succeeded another, characterized by the rich fauna of the Calcaire Grossier, and accompanied by a profuse exhibition of Nummulites, which had not been found in the underlying, or London, group; and to this section, on similar principles, Mr. Prestwich gives the name of the "Paris Tertiary Group."

In his former paper the author established the synchronism of the lower member of this group in each country, namely, the unfossiliferous Lower Bagshot Sands of England; the partially fossiliferous Upper Ypresian System of Belgium; and the Nummulitic Lits Coquilliers and associated sands of France, or Glauconie Moyenne of M. Graves;—in the present it is his object to separate, as it were, another layer, by placing the Bracklesham Sands and Barton Clay in correlation also with synchronous formations of Belgium and France. In this inquiry the author limits himself to the marine beds of the Bracklesham and Barton periods, reserving the investigation of the strata which subsequently exhibit freshwater conditions for a future occasion, and uses the Mollusca principally as his elements in the discussion. Now the Bracklesham Sands are 500 feet thick in the Isle of Wight, whereas the Calcaire Grossier, with which they are to be compared, does not exceed 140 or 150 feet; but, on the contrary, the Calcaire Grossier has supplied 824 species, and the Bracklesham Sands only 451, or of Mollusca alone 651 and 368 species respectively;—and thus the difference, both of physical characters and of the relative richness of the faunæ, naturally leads to the judicious observation, that in such inquiries it is necessary to follow out each bed laterally in space, in order to ascertain whether the change in the fauna, as well as in the mineral condition, is also progressive laterally. Mr. Prestwich gives a list of 171 Bracklesham mollusca which also occur in the Paris Tertiaries, and exhibits their distribution in the Paris beds thus:—

	Lits Coquilliers and	Calcaire Grossier.		
Sables Inférieurs or London Group,	Glauconie Moyen. Base of Paris Group,	Two Lower Divisions,	Two Upper Divisions,	Sables Moyens,
15.	75.	141.	43.	94.
		142		

This table exhibits very strongly the much closer organic analogy of the Bracklesham Sands with the Calcaire Grossier, taken as a whole, than with even a lower or upper member of the Paris group, whilst it separates them widely from the underlying London group; but it is curious to observe how little difference there is between the organic proportions if compared with only the two lower members of the Calcaire Grossier and with the Sables Moyens. The Belgian equivalent is considered to be the Bruxellian system of sands, siliceous and calcareous; and, of the 113 fossils they have furnished, the following is the distribution of those common to England and France:—

England.			France.		
London Group,	Bracklesham Sands,	Barton Clay,	Lits Coquilliers,	Calcaire Grossier,	Sables Moyens,
15.	49.	32.	43.	73.	56.

Mr. Prestwich has not compared these fossils with the Sables Inférieurs in France as in the former case, but the table again marks strongly the great difference of organic analogy between the Belgian beds as compared with the London group and the Bracklesham beds, thus indirectly confirming the propriety of separating the two latter.

If we compare again the proportions of the several English sections with those of the French, we find the per-centage thus—

London Clay, 16.	Bracklesham Sands, 51.	Barton Clay, 37.
Lits Coquilliers, 25.	Calcaire Grossier, 42.	Sables Moyens, 33.

And although, the Lits Coquilliers and the London Clay are not exactly in the same relative position in these comparisons, it must be admitted that the indirect evidence afforded by the Bruxellian series is strongly in favour of the next step of correlation, namely, the identification as a synchronous deposit of the Barton Clay with the Sables Moyens. This question is indeed worked out with great care, not only by a reference to the proportion of Barton species found in the several sections of the English and French Lower Tertiaries, but also by another species of comparison which is at once natural and philosophical, namely, that of the variation upwards in each distinct basin or organic region :—

IN THE ENGLISH.		IN THE FRENCH.	
Barton	30	Sables Moyens	35
Bracklesham	100	Calcaire Grossier	100

or taking the per-centage in a downward direction—

Barton	100	Sables Moyens	100
Bracklesham	45	Calcaire Grossier	50

so that this portion of the question seems most satisfactorily answered, although it had difficulties of no ordinary kind in its way. The next question is, whether the Laeken beds, or those above the Bruxellian, should be classed with the Sables Moyens, as the correlation of the Bruxellian with the Bracklesham would appear to imply; and this, though Mr. Prestwich gives strong reasons in favour of the correlation, he leaves open for future discussion. Taking, however, the proportion he has adduced in an ascending order, in respect to the species as follows,—

Laeken Beds	27	Barton	30
Brussels Beds	100	Bracklesham	100

and combining it with the fact of positive superposition, I think the probability is greatly in favour of the correlation of the Laeken Beds, Barton Clay, and Sables Moyens. I will not attempt to give here an analysis of Mr. Prestwich's reasonings in respect to the physical relations of the several basins to each other, such as the progressive approximation in mineral character as the French series ranges towards the English area; or the difference in the floras, which appears to imply that whilst there was a sea connexion between the basins, the land areas were different or disconnected; they can be only satisfactorily followed in a patient perusal of the paper itself, and I will therefore merely add, that in the preparation of the lists of fossils, and in the careful digest of the evidence they afford, Mr. Prestwich has fully maintained his position in this most difficult branch of geological science.

January, 1857.—Another paper was read by Mr. Prestwich on the discovery recently made of a fossiliferous ironstone on the North Downs, alternating with sand and gravel, and forming isolated masses totally distinct in origin from the outliers of an Eocene period, which other observers, especially Dr. Buckland, had before quoted as the evidence of a once continuous covering of such deposits having been spread over the surface of the chalk. This deposit Mr. Prestwich allots to the more recent tertiaries, namely to the Crag, and his proof depends on the identification of the masses on the Downs with the ironsand found in sand-pipes of the chalk at Lenham, near Maidstone. Mr. R. Jones had previously associated this ironsand with the Basement-bed of the London Clay, but the fossils found in it have been examined by Mr. Searles Wood, and pronounced by him to be those of the Lower Crag. Mr. Prestwich concludes that a deposit of that epoch had formerly spread over the chalk surface, and by the wearing away of the subjacent chalk by solution, had been let down into the sand-pipes thus formed. This theory is advanced in order to remove the fossils from the class of drift deposits; and the rare presence of a fossil in the ironstone of the North Down masses then serves to bind them on to the presumed overlying deposit of Lenham, and further, to similar deposits on the Downs between Calais and Boulogne, on the top of Cassel Hill, near Dunkirk, and at Diest in Belgium. To my own mind the evidence is at present scarcely sufficient for settling so important a question; but the subject is of so much interest, as bearing upon the physical changes which have taken place, that it deserves the most careful attention. It leads, for example, Mr. Prestwich into some curious speculations on the epoch, or epochs, of the denudation of the Weald: as first, he assumes a partial elevation of the anticlinal axis of the Weald during the cretaceous period, after which lower tertiary deposits were formed from the debris of the shattered rocks, and distributed over the area thus produced. Then in the later tertiary period it was again elevated, and a fresh denudation was the result; some island or islands of the lower cretaceous rocks still remaining within the area and supplying materials for the formation of the sandy ferruginous Crag-beds; and finally, that another great elevation and denudation affected the Weald, leaving outliers of these pliocene beds resting on an old flint drift on the very edge of the upraised chalk escarpments of the Weald. Mr. Prestwich, whilst thus enumerating a succession of elevations, meant doubtless to include intermediate depressions also, which seem to be absolutely necessary for the production of such results. Again, Mr. Prestwich connects this last elevation with the well-known climatal difference between the fossils of the lower and upper Crags. Before it, he observes, the first Crag-sea was open to the south, and of considerable extent; but the last Wealden elevation, cutting off the southern portion, so altered the hydrographical conditions of the period, that a sea open only to the north remained, in which the Red or upper Crag, with its boreal fauna, was then deposited. The fact that some change had cut off the advance of southern Mollusca into the Red Crag sea can indeed be scarcely doubted; but let it be remembered that no other than a land barrier, such as that suggested by Mr. Austen, could have been efficient for such a purpose, as the advance of mollusca, or at least the progressive transport of their ova, could not have been stopped by a mere shallowing of the water; and, if such a land barrier had existed to so late a period, each previous elevation ought to have induced similar climatal changes in the tertiary deposits then forming. In making these remarks, and many more might be added, I am only desirous to impress upon everyone the extreme difficulty which must ever attend upon attempts to trace the physical phænomena of past geological epochs, and to do honour to those who are daring enough to undertake a labour so arduous.

At this point I may mention the opinion of M. Ami Boué, one of our foreign members, that the English Channel has not been formed by excavation alone, through the action of water, but owes its origin to a line of fissure or disturbance. The remarks which have already been made all tend to support this view; but the great question, at what precise epoch internal disturbance produced this fissure, requires still further investigation before it can be satisfactorily answered.

In addition to the paper already noticed, we are indebted to our most able and zealous fellow-member, Mr. Godwin-Austen, for having so well performed the duties of a friend and of a geologist, by editing the last work of the distinguished and never-to-be-forgotten (for how can the labours of such a man ever die from memory?) Edward Forbes.

The indefatigable Prestwich is quoted by Forbes as the person on whose published researches he intended mainly to found his own, though he gives the warmest praise to the late Thomas Webster, as the first person, who, at a time when geological science was in England just beginning to assume a name and character, comprehended the general nature of these curious and varied deposits.

The researches of Cuvier and Brongniart had brought to light the curious fact, that in the basin of Paris there exists a succession of beds, which exhibit alternately marine and freshwater deposits, and this wonder, as it was then considered, was shown by Webster to be repeated in the Isle of Wight, and the general identity of the deposits determined. Ever since that period it has been the effort of some of our most able geologists to reduce the whole series of beds, collectively and individually, into coordination with the foreign equivalents, a labour of no ordinary kind; for however easy it may be to coordinate a whole system in one country with that of another, few operations are more difficult, or require more care and patience, than to compare every petty link in a great succession of beds of one country with that which was forming exactly at the same epoch in another; the sand which was washed up on one shore, perhaps even the sand-dune which was blown up on it, at the same instant when a calcareous deposit was precipitating from the water, or a mud-bank forming at some other and distant point; indeed, I have already said that it would be no easy matter to work out such a problem, as regards the recent, or now-forming deposits, were we furnished only with the data afforded by the relics of their organic inhabitants. The labours of Mr. Prestwich in this line we have already dwelt upon; and in this posthumous work we have set before us the most recent of those of Edward Forbes, valuable at once for the practical matter it contains, and for the further proofs it affords of what we might have expected in the higher and most philosophical speculations of our science, had our lamented friend been still spared to us.

The whole series of Eocene or Lower Tertiaries of the Isle of Wight is thus stated in a descending order:—Hempstead Series, Bembridge Series, Osborne Series, Headon Series, Barton Series, Bracklesham Series, Lower Bagshot Series, London Clay, and subjacent members of the Lower Eocene. By comparing this list with those previously published, it will be observed that Professor Forbes had discovered a group of sands, marls, and clays, to which he gave the name of Osborne Series, from their occurrence within the royal demesne, and that he intercalated it between the Bembridge and Headon Series.

In the distribution of these groups a nearly similar arrangement is adopted to that proposed by Mr. Prestwich, as the Bracklesham and Barton Beds are associated together as the Middle Eocene, just as Mr. Prestwich considers them to constitute, with the Lower Bagshot Sands, the Paris Tertiary Group; the Headon Series, Osborne Series, and Bembridge Series constituting the Upper Eocene. As on the first reading of his paper by Mr. Prestwich, the Paris Group was designated Middle Eocene, the terms Middle Eocene and Paris Group appear synonymous, and in truth in any attempt to classify these beds in groups the organic approximation between the Bracklesham and Barton Series in England, and between the Calcaire Grossier and Sables Moyens in France, must render it very difficult to form any natural separation between them. For drawing the upper limit of the Eocene, as Professor Forbes has done, so as to exclude from England all Miocene deposits, very strong reasons are adduced; these lines of demarcation will, however, vary according to the view taken by different geologists * of the relative importance of the organic evidence made use of. This work forms part of the publications of the Geological Survey, and Mr. Austen has been assisted in several parts of it by Mr. Salter and Mr. Bristow, members of that establishment, as well as by Mr. Morris and Mr. Jones. The ample tabulated, or as they might be properly called, statistical details, on which the several geological deductions have been founded, mark most strongly the care which as editor Mr. Austen has bestowed upon the work; and it is only

* During the progress of this address through the press, the Supplement to the 5th edition of the 'Manual of Elementary Geology' has been published, in which Sir C. Lyell separates the Barton Clay and its equivalents, the Sables Moyens and Laeken beds, from the Middle Eocene, leaving the Bracklesham Sands as their only English representative.

right to express also the obligations which all geologists must feel to Sir R. I. Murchison for the zealous manner in which, as Director of the Survey, he has promoted the publication of the last scientific researches of Edward Forbes.

In the papers which have passed in review before us, the comparison has necessarily been made between the English and French Tertiaries, and the terms of the comparison have principally depended on the catalogued Mollusca then known. But now, after the many years which have been devoted to the study of the Paris Basin, M. Deshayes resumes his labours, and in the first two parts of a new 'Description des Animaux sans Vertèbres découverts dans le Bassin de Paris,' brings forward so many additions to the formerly known fauna, that Tertiary-geologists will probably have to revise their calculations, if not their conclusions. M. Deshayes, in his introduction, points out also the interesting fact, that our knowledge of the recent fauna has gone on advancing with that of the fossil, the list of 5000 living mollusca having in thirty years been quadrupled in number, or raised to 20,000 ; and, as every day increases the number, either the organic difference between the existing and the Tertiary epochs must have been lessened or augmented, according as the newly discovered Mollusca have afforded a greater or less per-centage of species common to the two periods than that derived from the former lists. In a similar manner the discovery of additional Tertiary species must either narrow or widen the difference between the recent and ancient faunæ, in proportion as more or less recent species are found amongst them.

The results of the new researches have been most surprising : M. Deshayes observes, that a study of the phænomena leads to the first grand division of the Paris Basin into three deposits of two periods, each, of course, capable of further subdivision. The first deposits after the Chalk period were generally of a sandy nature, but the *most ancient of all* is the most interesting, as affording indications of the existence of dry land, and of an extensive lake. Within this lake lived lacustrine animals, with the remains of which were mixed those of mud animals in the marly deposits, which were then spread over the bottom of the lake. These fossil remains are classed under the designation of the fauna of Rilly, which, though unknown at the time the first work of M. Deshayes was published, has, through the labours of M. Boissy, since dead, yielded thirty-nine species. According to this statement, the Tertiaries commence in the Paris Basin by a freshwater formation, not by a marine one as in that of London. To the Rilly series succeeds a marine formation of sand of very considerable extent, and, in some of its beds, rich in fossils ; Beauvais, Bracheux, Noailles, and other localities are named, besides Châlons sur Vesles, at which and another point the recent researches of M. Deshayes have made known 100 species, almost all new. To this follows the series of Soissons and Laon, the sands of which contain beds of lignites ; and here by M. Tilley have been found many new species, as well as near Laon, in a deposit belonging to, and on the northern edge of, the Upper Calcaire Grossier.

Above the Lignites is another marine deposit, the fauna of which has been greatly extended, M. L'Evêque having collected 300 species from the single locality of Cuise La Mothe; but between the lignites and the sands of Cuise La Mothe there is a deposit rich in freshwater shells, and yet mixed with numerous marine species, including a bed of oysters, as at Bracheux; a large number of new species has been found in this interesting deposit. The sands of Aizy, near Soissons, are remarkable for the vast number of Nummulites which they contain, this being the earliest portion of the Paris Basin in which these fossils appear. This first nummulitic system is, however, quickly buried, when, strange to say, another, and still more extensive one appears in the sands of Cuise La Mothe, which again, after the extinction of the two species of which it consists, is replaced by a third system of nummulites, on the level of which is the middle division of the Paris Basin, or the Calcaires Grossiers. The Calcaires Grossiers, so long and carefully examined, still continue to pour out new treasures. At Grignon, Lamarck and Defrance collected 300 species; to that large number Deshayes added 100; but M. Caillat, without leaving the park of Grignon, has collected 600 species, of which 100 are new, some of them remarkable as exhibiting forms not before known in the Paris Basin. In the department of the Oise, M. Barbur has found a large number of new species, and M. Burdo also, including several Terebratulæ; so that I may well repeat that fresh comparisons of the Tertiaries of England and other countries will be required after the completion of the work of M. Deshayes, which, though called a Supplement, will really be fully as important as the original work. The sands of Reims, superposed on the Calcaire Grossier, are, from their fossils, considered only the upper part of that formation, which has there assumed a sandy type. The Sables Moyens, or Grès de Beauchamp, though distinguished from the Calcaire Grossier by some of the fossils, ought still to be associated with it, in the opinion of M. Deshayes, in consequence of the large number of Calcaire Grossier fossils which had evidently lived within the period of their deposition:—"With the Sables Moyens," observes M. Deshayes, "terminates, in the Paris Basin, a long period during which there is no appearance of any violent interruption from great convulsions. The beds succeed each other regularly, and, whilst the lower sands are united with the Calcaire Grossier by many common species, so is the Calcaire Grossier connected with the Sables Moyens in a similar manner." At this point, however, a change occurs, and M. Deshayes cites the opinion of M. Elie de Beaumont, that everything below the gypseous deposits is in the lower section of the Tertiary or the Eocene, and everything above it, up to the Fontainebleau sands, in the middle section or Miocenes; but, after carefully examining the fossil evidence, and noting the extraordinary analogy between the fauna of the Fontainebleau sands and that of the Calcaire Grossier, he declares that the analogy is greater than between the Fontainebleau sands and any other member of the Tertiary series, and that they must be considered as appendages to the Eocene, rather than as members of the Miocene deposits. In the Alps, indeed, MM. Hébert and Renevier had found the characteristic species of the Fontainebleau sands, mixed in a large proportion with those of the Sables Moyens, so that the two faunæ must there have been simultaneously existing in the same sea, confirming Deshayes' opinion that the Fontainebleau sands are really the upper portion of the Paris Basin beds; an opinion further confirmed by the discovery of a nummulitic stratum in these Alpine deposits, which thus connects the sands with the Eocene, so charged with Nummulites in the Paris Basin, and separates them from the Miocene, in which hitherto these fossils have not been found. These opinions of Deshayes seem strongly to confirm the accuracy of Mr. Prestwich's views; as the Middle Eocene would naturally be terminated by the Sables Moyens and Barton Clay, and the Fontainebleau sands would terminate the Upper Eocene; still leaving England without any representative of the Miocene.

It is unnecessary at this moment to go further into the details of this work, and I shall therefore only remark that the wide separation of the Fontainebleau sands from the Faluns de Touraine, though they were once confounded together, is pointed out; and that "the great nummulitic" question is ably discussed, as well as that of a supposed transition between the cretaceous and tertiary deposits. The decision on the first is, that nummulites first came into existence in the Eocene period, and are characteristic of that epoch throughout the world; and on the second, M. Deshayes observes, that "without hesitation he may still maintain his statement of 1831, that *no one species* has been as yet proved to be common to the Cretaceous and to the Tertiary faunæ;" and, further, that there is a difference equally abrupt and absolute between the two floræ. "The total extinction of all living creatures," he then goes on to say, "at a definite geological epoch, is certainly one of the most wonderful phænomena exhibited by the laws of creation,—the more remarkable, in this instance, as the successive formations do not exhibit in themselves any evidence of those convulsions which appear to have at least accompanied the work of extinction at other epochs. How much, too, must our astonishment be increased when, from the proof set before us, we are called upon to recognize between the first appearance of organized beings and the age of man no less than five repetitions of the great phænomena of Destruction and Re-creation!"

These words show that M. Deshayes still adheres to the Cuvierian doctrine of successive creations, whilst, however, he admits the extreme difficulty of some of the specific determinations on which this theory must mainly depend. It would, however, appear that M. Deshayes is not insensible, at least, to the philosophic difficulty of successive creations, in which species, though not absolutely reproduced, are replaced by others so nearly the same as to indicate almost a playful exercise of creative power, since in the following passage he advocates only one exercise of creative will: "In spreading over the surface of the earth organized beings, the all-powerful Creator has left nothing to chance. In the progression which is exhibited as well in the combinations as in the successive increments of organic beings, a simple formula may be discovered which has regulated creation from the beginning to the present day; and I believe, as I have ever done, that the great whole of organic creation has been produced, by the aid of ages indeed, but uninterruptedly and from one single act." This is a remarkable approximation to the theory of development; for what does the passage imply, unless it means that those laws of periodic change which have been imposed on individual existence should be also extended to genera and species? Hereafter, I may refer again to this subject; but at present let me simply add that, if we admit the absolute difference as creations between the Tertiary and Cretaceous systems, we cannot disunite the Tertiary from the existing creation, but must, as I feel satisfied will ultimately be the case, see in the records of Tertiary organic life only the evidence of an earlier epoch in the history of the world we now live in.

In reference to this subject, Dr. De la Harpe has published in the 'Bulletin de la Société Vaudoise des Sciences Naturelles,' a brochure which he calls "Quelques Mots sur la flore tertiaire de l'Angleterre." Whilst Miocene strata have contributed a copious flora, the Eocene have afforded few localities rich in vegetable fossils; a fact which M. De la Harpe explains by another, namely, that in Europe, during the Eocene period, lacustrine shore or land deposits were of rare occurrence; so that, whilst the marine vegetation of seas of the Eocene period is tolerably known, that of its continents has as yet been but imperfectly studied. As localities, where the Eocene flora has been carefully studied, the author names the Isle of Sheppey, Sotzka in Styria, Sagor in Carniolia, Hæring in the Tyrol, and Monte Promina in Dalmatia; but of all of these, except the Isle of Sheppey, he considers the Eocene origin to be doubtful, as a very large number of their species have been found in various Miocene deposits, more particularly in the lower beds of the Swiss Molasse. M. De la Harpe, whilst in England, was enabled to examine some of the best collections of Eocene vegetable fossils, such as those in the possession of Mr. Bowerbank, Mr. Prestwich, and the Museum of Practical Geology, and carefully went through them in reference to the now generally recognized divisions of Lower, Middle, and Upper Eocene; and he remarks, after detailing the results obtained in each division, that, "should he have succeeded in exciting in English geologists a closer attention to this branch of Fossil Natural History, and in dissipating the doubts which have been raised as to the importance and certainty of its results, his end will have been gained." I dwell upon this, as nothing can be more unsatisfactory than to suppose that the world of plants should have been built up upon other principles than the world of animals, and, I would venture to suggest, more opposed to experience, as there is assuredly as strict a limitation, perhaps even a stricter limitation in the regions of plants, than in those of the lower animals. From the conditions of the vegetation, the author considers that the dry land of the Eocene epoch consisted of hills and vast, dry, and sandy plains; some magnificent forests of a varied character existed, and the general conditions of soil corresponded in character rather to the sub-tropical regions of Africa and South America, or of Australia, than to the more temperate regions of Europe or South America.

The great difference between the flora of the Eocene and that of the Miocene epoch is strongly insisted upon, M. De la Harpe stating "that there exists, from the lower Tertiary formations upwards, a gradual mutation in the vegetation, which tends to approximate it by slow degrees to the existing flora of our own climate; and yet, that scarcely any one species has passed the boundary of the Eocene to penetrate into the Miocene, and not one of the Miocene plants has been perpetuated into the existing flora." So that, in this respect, remembering that the deduction is applicable only to the *terrestrial* flora, the evidence derived from plants is even more sharp and rigid than that afforded by at least the lower animals.

The singular character of the Eocene flora, in which are mingled together the plants of various climatal regions, may be appreciated from the following summary of the flora of the Isle of Sheppey:—

Coniferæ	13	species.	Leguminosæ	47	species.
Nipaceæ	12	,,	Malvaceæ	10	,,
Aurantiaceæ?..	1	,,	*Proteaceæ*	2	,,
Cucurbitaceæ ..	1	,,	Sapindaceæ	15	,,

Under this assemblage does not the presence of two species of Proteaceæ suggest naturally the reflection, that, whilst so early as the Oolitic period, an Australian fauna prevailed in the present European region, the appearance of such plants in the Tertiaries may be assumed to indicate, as it were, the gradual retreat of the flora, or, in other words, the shifting of the climatal and other conditions of the earth's surface to the present Australian region? Various figs of large size, a poplar, a maple, three laurels, numerous Leguminosæ occur, with some other familiar genera mixed with Proteaceæ at Alum Bay; and M. De la Harpe observes, after reviewing the peculiarities of each separate locality, as at Corfe Castle, that it seems impossible to divide the Eocene strata into distinct sections by the flora alone, although the separation between the Eocene and Miocene appears to be marked in the strongest manner.

The tertiary deposit of the Isle of Mull, described by the Duke of Argyll, is the only one in Great Britain, which, in the author's opinion, can be classed with the Miocene formation, so that he is in accordance with Mr. Prestwich as respects the limits of the Eocene formation in England. The following Table exhibits the result of M. De la Harpe's inquiries as regards the distribution of the species found in each of the localities which have supplied materials for investigation, the per-centage being attached in each case of comparison:

Localities.	Number of Species found in each.	Reading.	Counter Hill.	Alum Bay.	Bournemouth.	Corfe Castle.	Sheppey.	Bracklesham Bay.	Fluvio-marine Series.	Upper Eocene.	Species peculiar to each locality.
Reading	9	9	....	3 = ·33	....	1 = ·11	....	....	....	....	6 = ·66
Counter Hill....	3	....	3	1 = ·33	1 = ·33	....	....	....	....	....	1 = ·33
Alum Bay	43	3 = ·07	1 = ·02	43	13 = ·30	7 = ·16	....	....	....	....	26 = ·60
Bournemouth ..	21	....	1 = ·05	13 = ·62	21	5 = ·24	....	....	....	....	8 = ·38
Corfe Castle....	10	1 = ·10	....	7 = ·70	5 = ·50	10	....	....	....	....	3 = ·30
Sheppey	102	....	....	....	....	....	102	2	....	....	100 = ·99
London, &c...	Total unknown.	....	....	....	....	....	All.	....	....	....	....
Bracklesham Bay	3	....	....	....	....	....	2 = ·66	3	....	....	1 = ·33
Fluvio-marine ..	6	....	....	....	....	....	....	....	6	3 = ·50	3 = ·50
Upper Eocene ..	6	....	....	....	....	....	....	....	3 = ·50	6	3 = ·50
Ardtun, Isle of Mull.....	7	....	....	....	....	....	....	....	....	....	7 = 1·00

Dr. De la Harpe does not attempt to carry out fully the floral correlation of these deposits with those of the world at large, as he frankly admits the imperfection of the data for such a purpose, though he brings forward strong evidence for supporting his opinion, that the Austrian deposits are really Miocene, and should not therefore be allowed to embarrass calculations founded upon more certain Eocene data.

The East India Company has lately exhibited a great anxiety to advance Geological Science, and, by the establishment in India of a Museum of Economic Geology, has shown that it is not blind to the great national advantage of possessing such an establishment. The first regular report which has reached this country and has been drawn up by Mr. Oldham, who presides over the Geological Survey, is on the Irrawaddy River, and embraces a distance of eighty miles, extending to Ava through Prome. Along the river nothing but tertiaries occur—the strike corresponding to the river channel; clay, shales, and sandstones forming an Eocene deposit, as determined by the Prome fossils brought home by Crawford and Wallich. Over these, unconformably deposited, is a more recent deposit, supposed, from the similarity of the fossils in some cases, and the identity in others, to be in a parallel with the Sevalic group of India. Mr. Oldham provisionally considers them Miocene. A coal-deposit exists in the Eocene beds, with a north and south strike, being about the same as the average direction of the igneous rocks, which form, as it were, two uplifting belts, one on each side of the river. A vast alluvial tract is also exhibited on the east bank of the river in the lower portion of the district described, the tertiaries occupying patches on the west bank. This survey was directed principally to the examination of the coal, and is therefore not illustrated as to the fossils, though it is in respect to physical features.

Capt. Spratt has communicated during the Session, a paper on the Geology of Varna and the neighbouring parts of Bulgaria. This district he divides into two formations: the lower fully 1000 feet thick in some localities, and consisting of yellowish and grey calcareous sandstone and sandy marls, with an occasional interstratified oolitic bed, he considers Eocene; and the upper, which is unconformable to the lower on which it rests, consists of red sand and marls, seldom more than 100 or 200 feet thick, though at Cape Aspro, fifteen miles south of Varna, it attains a thickness of fully 1000 feet.

The lower or Eocene formation is of marine origin, contains many fossils, and at the upper part of the Lake Allahdyn an abundance of Nummulites, none of which have been found near Varna. In the list of fossils drawn up by Mr. J. Morris and Mr. Rupert Jones, two species are named, viz. *Nummulina distans* and *N. granulosa*; and, as Capt. Spratt mentions that the more durable calcareous stratum is usually the uppermost bed, is only about 25 or 30 feet thick, is charged with Nummulites, and is underlaid by arenaceous marls and sandstones fully, as at Devno, 1000 feet thick, it appears here, as in Western Europe, that, prior to the appearance of the Nummulites, a considerable deposition of sands and marls had occurred, thus apparently carrying these beds up to the middle Eocene period. The hard nummulitic rocks at Allahdyn, near Varna, in Bulgaria, have been worn into isolated pillars, as also into cavernous excavations, the openings of which are divided by rude pillars. So artificial is the appearance of these relics of a former continuous stratum that they had been supposed to be the remains of some ancient temple; but the improbability of such a supposition was pointed out by Col. Hamilton, of the Grenadier Guards, and is reiterated by Capt. Spratt, who adduces examples of many partially formed pillars, where the work of disintegration and wear has not advanced so far. The explanation of this phænomenon is by no means easy, and the only analogous cases which I remember, are those of the Flower Pots in Lake Huron and on the north coast of the St. Lawrence (Mingan Islands), where, however, the isolated masses, being still subject to the action of the Lake and River waters, are abraded more at the bottom than at the top, and have therefore assumed the form of inverted cones*. Capt. Spratt considers the pillars to be the result of subaërial meteoric agencies, but I am more inclined to attribute their present condition to the action of lacustrine waters, highly charged with carbonic acid, an idea which Capt. Spratt seems also to have had in his mind, and to have considered probable, though he adds that his "impressions on the spot were favourable for an aqueous degradation and waste at a recent period, and in fact now in process under the atmospheric influence,"—a mode of production, let it be in fairness remarked, which though not so consistent with the uniformly rounded surface of the pillars, is strikingly so with the formation of the nummulitic sand at the base of the pillars. It is remarkable that a group, supposed to be of similar pillars, occurs submerged in Varna Bay, so that, if an identity can be established between them as parts of one stratum, it is probable, as Capt. Spratt suggests, that Devno Valley and Varna Bay have been formed by a depression of comparatively recent date.

North of Varna, the lower series of limestone and marls continues in a line of steep banks or cliffs to near Mangalia, where the overlying reddish sands and marls appear and form the steppe-country of the Dobrudscha. These deposits are well seen at Baljik, where a marly bed 150 feet thick, with many marine fossils of a small size, occurs at the base and is apparently an upper member of the Varna series. Foraminifera are abundant, and, in the opinion of Mr. Rupert Jones, are with one exception those commonly found in shallow water. A mass of white chalky-looking marl 200 feet thick, and containing only casts of a small bivalve, like a Cardium, resembling that in the freshwater deposits of the Dardanelles, overlies the lower marine bed, nearly, but not quite conformably, and passes upwards into white and greyish marls replete with freshwater shells, associated sometimes with the above-mentioned Cardium, so that the conditions

* Geol. Trans. 2 ser. vol. v. p. 93. Somewhat similar phænomena are figured and described in Lieut. Nelson's paper on the Bermudas, *ibid.* p. 120.

appear to have varied from marine to brackish, and then from brackish to fresh water; land being adjacent, as abundant specimens of Helix occur in the upper portion of the series. The freshwater origin of the Dobrudcha sands and marls is further confirmed by the Kustenjeh section, where a fragment of the tusk of an elephant was found in the lower bed of grey marl which rests upon a yellowish fossiliferous limestone, probably a member of the nummulitic series, and is overlaid by about 70 feet of clays, marls, and gypseous bands, the lower of which contain casts of *Cyclas* or *Cyrena*.

Capt. Spratt then points out the remarkable resemblance between the red marly cliff which extends from Balbek, in the Crimea, to Eupatoria, and the second, or more recent, group of deposits on the coast of Bulgaria, and doubts, therefore, the supposed Miocene origin of the former. The general resemblance between these deposits and those which overlie the Eocene freshwater beds of Samos and Eubœa, as well as the freshwater deposits which, in the Thracian Peninsula, attain a thickness of 500 or 600 feet, naturally leads to the belief that they are of Pliocene date. There are also Post-tertiary deposits and drifts of a very late period, but Capt. Spratt explains that he has taken every care in separating the fluviatile and lacustrine deposits he describes, from any member of the northern drift. Another interesting remark is, that a submarine connexion between the mountain ranges of the Balkan and Taurus can be traced across the Black Sea, along the edge of a remarkable submarine plateau or steppe; and, connecting this fact with the great extent of these freshwater deposits, and with the Aralo-Caspian deposits, we see the evidence of a sudden alteration in the physical conditions of the country at a very recent epoch, so recent, indeed, as almost to touch upon the existing epoch. Although I shall have to notice it again, I may conclude these remarks by stating that Capt. Spratt discovered the bones of a snake in the freshwater deposits of the Macedonian coast at Thessalonica.

Captain Spratt contributed also a second paper to the Society; but, as he is still pursuing his inquiries into the nature of the Tertiaries of this portion of the earth, I will reserve my further observations until I shall be able to give a view of the value of his labours. I will, however, take this opportunity of recording the completion of a Geological Map of Malta by the Earl of Ducie. That nobleman based his own researches on those of Capt. Spratt, and it is gratifying to learn that he fully confirms their accuracy, though he does not entirely concur with him as to the propriety of establishing so many subdivisions in the tertiary deposits of Malta.

I will now notice that part of the paper of my friend Signor Cocchi, on the igneous and sedimentary rocks of Tuscany, which refers to the Tertiary formations, as it is of importance to keep in view the extraordinary difference between the physical conditions of deposits of the same age on the borders of the Mediterranean and on our own coasts. We have, for example, seen that the Tertiary deposits commence with us by the group of the London Basin, and that there exists therefore a great thickness of deposits of a very marked character between the chalk and the portion of the Paris Basin in which Nummulites occur. On the Mediterranean, however, such is not the case, as the mineral deposits of succeeding formations appear to blend into each other in such a manner that no geological difference would be suspected were it not for the appearance of characteristic fossils. Signor Cocchi, for example, describing the upper portion of the cretaceous formation, notices the Calcaire Albérèse, a compact limestone of very fine grain and of a yellowish colour, though frequently varied by the presence of foreign substances, and often exhibiting a zone-like disposition of colours. In the south of Tuscany this limestone is replaced by another equally compact but more argillaceous, and coloured a greyish blue, like the neck of a pigeon. Both these limestones have been deposited in thin and almost schistose beds, and neither has afforded other fossils than Fucoids. In the Campigliese and the Isle of Elba, a powerful series of beds of a very fine-grained limestone occurs, the colour of which is sometimes rose, sometimes glaucous green, and sometimes pure white; the fracture is largely conchoidal and numerous dendritic crystallizations are highly characteristic. This deposit is largely developed in the Apennines; but all who have visited the Mediterranean must at once recognize in this description the familiar characters of the white limestone, such, for example, as it is seen at Corfu and elsewhere; but, as I found it often difficult at the latter place to draw a line between deposits of different ages, though succeeding each other without a mineral change, so also Signor Cocchi remarks that the same lithological forms being repeated above the nummulitic limestone, as were found below it, it is impossible to separate them from each other when the nummulitic deposit is deficient.

Proceeding to the Tertiary formations, Signor Cocchi observes, that the lower or Eocene member consists almost entirely of the Macigno and Upper Calcaire Albérèse; and then, subdividing it into two sections, he states that the nummulitic limestone, so well described by Murchison, forms the basis of the system, and constitutes the only satisfactory horizon between the Cretaceous and Tertiary formations, as it is almost impossible to draw a line of distinction between them in its absence. To the hard, compact, and granular nummulitic limestone, succeed argillo-calcareous schists and limestones with flints, so that Signor Cocchi remarks, that the series of deposits here brought within the region of the Tertiaries by the intercalation amongst them of the nummulitic limestone is a simple repetition of the mineral deposits, the *Calcaire albérèse* and *Pietra columbina*, of the Upper Cretaceous rocks. The characteristic fossil is the *Nemertilites Strozzii* (Savi and Menegh.), a gigantic marine worm. The Macigno, which is in its normal condition a quartzose grit with calcareous cement, is next described in all its varieties, some of which are very interesting, more especially the prismatic, in which the rock breaks up into rhomboidal prisms. Signor Cocchi observes, that it was during the deposition of the Macigno that the greater volcanic phænomena began to be exhibited and the Italian continent to be formed; but I shall not at present follow him in the exposition of the various igneous rocks erupted at this period. The upper section of the Eocene formation, though sometimes separated by palpable marks of discordance in stratification from the lower, is far more frequently in complete accordance with the lower section; so that in consequence of the lithological resemblance, a separation is sometimes attended with extreme difficulty; but here Signor Cocchi calls to his aid the evidence afforded by the erupted rocks; for, whilst the serpentine with diallage, or ancient serpentine, was evidently erupted subsequently to the deposition of the Cretaceous and lower portion of the Eocene deposits, which it traverses and disturbs, it was erupted antecedently to the Upper Eocene deposits, which contain many of its fragments. Amongst the rocks of eruption is numbered a true granite, the ordinary constituents of which are associated with tourmaline, from which circumstance it has been called tourmaliniferous and also modern granite, having been erupted subsequently to the deposition of the Eocene Macigno, fragments of which it contains imbedded in its substance. The felspar of this granite is sometimes in the form of petalite, and the mica also of a lithine base; but all the components are crystalline, and it is therefore a well-marked instance of the recent repetition of the granitic form amongst erupted rocks.

Of the Middle Tertiary beds I shall only mention the following,—the *Pietra lenticolare* of Parlascio, which consists entirely of one species of *Nummulites, N. Targioni*, Meneghini; the clays and the bituminous limestones which contain rich deposits of lignite (the *Mytilus Brardi* being a fossil of not rare occurrence); and the gypseous and salt-bearing clays of Volterra, which are allotted to this section. A serpentine without diallage was the erupted rock of the epoch, and Signor Cocchi also describes what he calls an hydroplutonic eruption, consisting of "torrents of mud forced up" through cracks or crevices, and carrying with them fragments of the rocks through which they passed.

In the Upper Tertiaries we enter on the ground so well described by Brocchi, that Signor Cocchi observes, little can be now added. To this epoch M. Savi assigns the bone-caverns, the species of mammalia which they contain being the same as those found in the celebrated freshwater deposits of the Val d'Arno, though Signor Cocchi remarks, that the same Elephants, Mastodons, and Hippopotami must have lived anteriorly to these deposits, as their bones have been found in the yellow marine sands at a lower level.

The comparison between the deposits of Val d'Arno and Leghorn has been thus given me by Signor Cocchi.

Upper Val d'Arno.	*Leghorn.*
Freshwater formation with *Elephas meridionalis*.	Upper Panchina with human remains.
	Lower Panchina.
Yellow sand with *E. meridionalis*.	Yellow sand with *Elephas meridionalis*.
Blue Clay.	Blue Clay.

Hence it will be observed that the *Elephas meridionalis* existed through a very extensive range of deposits, and that the Panchina deposit has continued from the age of the *E. meridionalis* up to the human period.

The recurrence of species apparently lost, or the re-appearance of the same physical species, is strongly marked by Signor Cocchi: he says, it is deserving of remark, that the species of the yellow sands are not those of the clays, but such a fact must not be used as an argument for a succession of creations, since it is observed that where there is an alternation of the clays and sands, there is also an alternation of the species corresponding to each; thus again bringing before us the necessity of restricting the views so long entertained of the abrupt lines of demarcation of successive faunæ.

On this subject I shall at the conclusion of my address say a few more words, and I shall therefore close my references to Signor Cocchi's paper, which deserves an attentive perusal, as it is rich in information on the general structure of Tuscany, by stating that he places the eruption of trachytic rocks within the pliocene epoch, and considers that the last great elevation of the Apennines, to which the present form of the country was due, took place within that epoch, and probably at the time of the trachytic eruption.

I have received, through the kindness of M. Pictet, a copy of a monograph, by himself and M. Alöis Humbert, of the Chelonians of the Swiss Mollasse, and I shall notice it here in order to afford another striking example of the local peculiarities which so strongly mark the tertiary deposits, and thereby increase the difficulty of placing those of distant and widely-separated countries in co-ordination with each other. In this work, after enumerating the writers who had previously treated upon the Chelonians of Switzerland, M. Pictet mentions the following localities at which he has himself found their remains: viz. 1, in the molasse of Vengeron, near Chambeisy, Canton of Geneva; 2, in the molasse and lignites of the neighbourhood of Lausanne; 3, in the molasse of Yverdun; 4, of Mount Molière, near Estavayer; 5, the molasse of the Cantons of Berne and Argovia; 6, the freshwater marls of Chaux de Fonds; 7, the molasse and lignites of Zurich and the east of Switzerland; 8, the celebrated Œningen deposits. These local deposits M. Pictet arranges in five distinct stages; the lowest being the freshwater molasse of the Cantons of Vaud, Berne, and Argovia, including that of Vengeron, which rests unconformably on the red molasse, the lowest member of the series.

This formation, or series of deposits, admits of subdivision into a great number of beds of considerable thickness; for instance, the grey or molasse proper 1260 feet thick, the red or lower molasse 995 feet, and others of very small proportions. The molasse with lignites of Lausanne lies between the grey and the red molasse: in the red molasse vegetable remains only have as yet been found; but both in the molasse with lignites and in the grey molasse, associated with the remains of vegetables, the bones of large terrestrial animals have been found, in addition to the Chelonians, the more immediate subject of M. Pictet's essay; and it is somewhat curious that these remains are not the same in the two deposits, the *Anthracotherium magnum* characterizing the molasse with lignites, whilst the grey molasse has produced the *Palæomeryx Scheuchzeri* and *P. minor, Rhinoceros incisivus, Mastodon angustidens, Hypotherium Meissneri, Microtherium Renggeri,* the remains of which still continue to be found in the overlying marine molasse. This change in the fauna is ascribed entirely to the change in the physical deposits; the lignites being apparently the product of marsh vegetation, and the *Anthracotherium* the natural inhabitant of a marshy region which would be unfitted for the residence of the *Rhinoceros* and *Palæomeryx.* The flora of the molasse with lignites differs as greatly from that of the grey molasse; and this difference is equally explicable, in the opinion of M. Pictet, by the more marshy character of the soil in which the species of the lignite beds had lived. These deposits are classed with the lower miocene. The freshwater marls of Chaux de Fonds, the marine molasse of Mont de la Molière, and the molasse of the north-east of Switzerland are classed together as the upper portion of the miocene. In the marl deposits of Chaux de Fonds the remains of the Chelonians are associated with those of the *Dinotherium giganteum,* of Stags either of the group *Palæomeryx* or *Dicrocerus,* of a *Rhinoceros,* of a *Mastodon,* of *Lophiochœrus Blainvillei,* of *Tapirotherium Larteti* and *T. Blainvillei,* and of some other mammals, indicating a fauna of great interest, the terrestrial range of which must have been far more extensive than the narrow limits of the deposits in which these relics have been found.

The celebrated freshwater calcareous deposits of Œningen, in which Murchison has recognized eleven distinct beds, Karg twenty-one, and Tschudi seventeen, are considered by MM. Pictet and Humbert as the most recent of the formations, and classed with the pliocene.

In addition to some indeterminable fragments, MM. Pictet and Humbert have distinguished and described 10 new species of Chelonians, making the total number of known Swiss species 28. But in addition to the interest which must attach to the discovery of so many new species, is that derived from the local character of each species; for example, the *Testudo Escheri,* Pictet and Humbert, appears to have ranged over the whole of the north-east of Switzerland at the end of the miocene epoch, having been found at four different localities within that area, but not beyond it. The *Emys Wyttenbachii,* Bourdet, a small *Emys* from Grüsisberg, and two species of *Emys* from the molasse of Argovia, described by Hermann von Meyer as *E. Gesneri* and *E. Fleischeri,* are, it will be observed, equally restricted in their habitats, so far as the present knowledge of the subject enables us to judge.

The freshwater marls of Chaux de Fonds have produced many fragments of Chelonians, though generally in imperfect condition. H. von Meyer had considered these fragments sufficient for at least the recognition of six species, but M. Pictet having the same materials before him considers all reducible to one species, which he terms *Emys Nicolei.* Pictet and Humbert thus, it will be observed, preserve a local difference between the fauna of these marls and that of either the north-east of Switzerland, or of the molasse of Mount Molière, associated geologically with them; this latter deposit having yielded the remains of at least four species, not absolutely determinable, though distinguishable from any of the preceding. The *Emys Laharpi*, Pict. and Humb., and the *Emys Charpentieri*, Pict. and Humb., were found only in the lignites of Lausanne; the *Emys Gaudini*, Pict. and Humb., the *Cistudo Razoumowskyi*, Pict. and Humb., and *Cistudo Morloti*, Pictet and Humb., in the molasse of Lausanne; whilst the fragments found in the contemporaneous molasse of Vengeron, though not sufficiently perfect to be accurately determined, are yet sufficiently so not to be confounded with the preceding species.

In addition to the land- and marsh-tortoises of the preceding deposits, various remains of fluviatile Chelonians have been found, which M. Pictet refers to at least three distinct species; namely, 1st, a true *Trachyaspis*, fragments of which have been found in the molasse of the Canton de Vaud and in the molasse of Mount Molière, so that these fragments, belonging to the same species, that is, the *Tr. Lardyi*, H. von Meyer, form an organic link between the two deposits; 2nd, a specics of *Trionyx* in the molasse of Yverdun; and 3rd, a species of either *Trionyx* or *Trachyaspis* in the lignites of Rochette. The deposits of Œningen have yielded no new species, but possess their own representatives in the *Chelydra Murchisoni*, Bell, and the *Emys scutella*, H. von Meyer.

What a curious picture of the former condition of Switzerland does this local distribution of the Chelonians afford, and how difficult to explain it, unless indeed the sluggish nature of these animals may be deemed sufficient to account for the limitation of their range of existence! MM. Pictet and Humbert appear to have taken great pains in comparing their species with those described by preceding writers, and, though the differences in some instances are small, it is probable that the species are really well-established. The Chelonians, however, of some tertiary deposits have not yet been described, and the authors therefore have been unable to bring the Swiss deposits into comparison with them; it can scarcely, however, be expected that species so locally restricted in Switzerland should be found to have a more general and enlarged range elsewhere.

I have dwelt thus long on these writers, in order to illustrate the necessity, in the present state of geology, of first co-ordinating together those members of the tertiary formations which appear to have had a geographical connexion between them, before attempting to extend that co-ordination to distant and strongly separated localities. The Mediterranean has now a fauna marked by many peculiarities, and its tertiary deposits were characterized by similar peculiarities; and, in effecting the more general correlation, it is therefore necessary to advance step by step in establishing the correlation of adjacent deposits before attempting that of the more distant.

Mr. Prestwich has pointed out the peculiarities of the Paris basin, as distinguished from those of the London basin, and suggested that the true mode of comparing two such parallel deposits, is by observing the proportionate variation in each; and such must evidently be the right system of comparison between distant deposits in which the amount of local variation so much exceeds that of general affinity. Here and there may be found some bed or beds so strongly marked by common characters, physical and organic (as, for example, the nummulitic beds in different countries), as to assure the mind of their contemporaneity; but all the other beds between them may vary so greatly in any two countries, as to admit only of an absolute arrangement in each individual section, and a general deduction from the proportionate relations between the two. The field, therefore, for the labour of geologists is still unbounded; and, if we pass from the limits of Europe, in which, moderate as they are, the difficulty of correlation is very great, to more distant regions, such as those of India or America, no just estimate can be formed of its magnitude. Look, for example, at the aspect of the tertiaries of India,—of that portion, for instance, described by Mr. Oldham, and it is evident how much has yet to be done to satisfy the mind of their contemporaneity with certain named deposits of Europe; and, if we refer to the very interesting work on the Pleiocene Fossils of South Carolina, by MM. Tuomey and Holmes, how remarkable do we find the organic individuality which the tertiary deposits of that country exhibit, as compared with those of Europe! Seven numbers have now been published of this work, and it may be fairly said that, in the care bestowed upon the descriptions and illustrations, it is deserving of great praise, and does honour to the publishers of America. The expense of bringing out such a work must necessarily be very great, and Mr. Holmes appeals therefore for support to "the pride not only of his own city and State, but of the whole country, and especially to the friends of natural science at large." The American government has never been niggardly in its efforts to promote science, as has been amply proved by the several geological surveys and other scientific works it has so liberally promoted and fostered, and it is hoped therefore that this important work may also receive its support and be adopted as a national work.

We have had a short paper on the Valenciennes Coal Basin, by MM. Degousée and Laurent, communicated in a letter to Mr. Tylor. This coal-basin is in the prolongation of the Belgian Coal Basin of Mons, and the present workings afford a striking example of the increased knowledge and energy of the present age, as in the last century France possessed in the north only the mines of Anzin, first worked in 1716; and, though many fruitless attempts were made to discover new sources of coal, the adventurers having been led into a wrong direction, namely towards Arras, it is only recently that the basin has been satisfactorily explored in the direction of the Pas de Calais. At present several companies have been formed, about £8000 expended, and 150 sinkings made, the result being a large accession of wealth to the two Departments in which the workings have been established. It is remarkable that the Valenciennes coal-deposit immediately underlies the chalk, or at least the cretaceous formation, as a thin bed of greensand is actually interposed between the chalk and the coal-deposit: in the Department of the Moselle, however, the coal is overlaid by the new red sandstone. This paper was accompanied by a useful map, showing the position of all the workings from Valenciennes, westward, to the Pas de Calais, a distance of about 100 miles; and the manner in which the outcrop of each member of the formation, from the lower devonian upwards, is shown by the use of letters, as L D, M D, for lower and middle devonian, D C, D L, Devonian conglomerate and limestone, L M L, lower mountain-limestone, L C, lower carboniferous, C M, coal-measures, deserves attention from its simplicity and effectiveness.

The labours of the Geological Society of Dublin have been lately directed to the investigation of the position of the Coal-formation of Ireland, and its relation to the Old Red Sandstone. Mr. John Kelly, formerly one of the most active assistants of Dr. Griffith, and now employed upon the Government Geological Survey, read a paper upon the subject, which has been published in the Journal of the Society. Conforming to the views expressed by Professor Phillips in his "Geology of Yorkshire," Mr. Kelly represents the carboniferous formation of Ireland as constituting a triple system, characterized by the prevalence of coal, of limestone, and of red sandstone; and, as regards Ireland, he observes that, though its subdivisions differ widely lithologically, the whole system is characterized—1st, from the strata of which it is composed resting unconformably on whatever rock lies below them; 2ndly, as being covered unconformably by the overlying rock; and 3rdly, as being parallel to one another, or lying, as it were, in one bundle. This statement implies that the mountain-limestone, coal-deposits, and old red sandstone are uniformly parallel or conformable to each other,—a view of the circumstances which, I suspect, cannot be established even in the limited area of Ireland. Of any great deposit of gravel and sand, the formation of which indicates a certain amount of violent action and of progressive movement, it must always be difficult to define the precise epoch, unless some of the organic relics of the period should have been preserved. This is the case in the old red sandstone, and it is only when in the lower beds certain Silurian fossils, or fossils closely analogous to them, are found, that the relation to the Silurian becomes manifest; just as in the other case the relation to the carboniferous strata is similarly established by the presence of carboniferous fossils. On this principle I have elsewhere urged, that, whilst the Old Red may be considered to graduate downwards into the Silurian, it may equally be considered to graduate upwards into the Carboniferous. Nor is local unconformability or local conformability sufficient to decide, or even to affect, this question. It appears, for example, from Mr. Kelly's statement, that at Lisbellaw a *brown stone*, or conglomerate, is conformable to the fossiliferous Silurian grey grits and slates,—this would be a violation of the first of his three great characteristics, were this rock to be considered a part of the Devonian or Old Red Sandstone; but Mr. Kelly separates it entirely from that formation, and supports his opinion by referring to various points in the South of Ireland where the Old Red Sandstone is seen to cap unconformably a brown sandstone. He says, "Besides the new red sandstone and the old red sandstone, we have in Ireland another red sandstone, or grit, which, I have reason to believe, has frequently been confounded with, or mistaken for, the carboniferous old red which I have been describing. It is of true Silurian age, as I shall presently show." To distinguish these rocks, so closely resembling each other, Mr. Kelly adopts the provincial term "brownstone," as used by the peasants of the country. The Old Red Sandstone itself Mr. Kelly divides into three sections; namely,—1st, a thin band of red conglomerate, composed of pebbles of white and brown quartz, purple hornstone, jasper, and fragments of other rocks; 2nd, alternating red sandstones and shales, between 200 and 300 feet thick; 3rd, yellowish sandstones with occasional intercalated beds of limestone or calcareous slate, containing the usual fossils of the mountain-limestone. This series is well seen at the Hook, county of Wexford, and there terminates in the true mountain limestone. The same view of the position of this series is taken by the Rev. Professor Haughton, who thus enumerates it from below upwards:—1st, Old Red Sandstone and conglomerate, resting unconformably on the nearly vertical beds of Silurian slates, alternating with each other, and about 1500 feet thick, without fossils; 2nd, alternating beds of red conglomerate, red micaceous sandstone, and red shales, 382 feet in thickness, containing remains of plants referred to *Knorria dichotoma*, thus representing the yellow sandstone; 3rd, older limestone, composed of a series of alternating beds of arenaceous limestone, black shale and sandstone, and red ochreous and flaggy limestones, the total thickness being 851 feet: many of the fossils are stated to be new, but others are well-known carboniferous fossils; 4th, dolomite-bed without fossils, 385 feet thick; 5th, newer limestone-beds alternating with calcareous shales, and containing the usual carboniferous fossils. Now, Professor Haughton considers the plant-beds of this section as equivalents of the yellow sandstone of Dr. Griffith, and as distinct members of the Carboniferous system, though constituting the Upper Devonian of the Government geological surveyors; and he further observes that it is impossible to draw any line of separation between these beds and the lower sandstones and conglomerates, so that "the group of rocks described is a continuous whole, and as such should be classed with the Carboniferous system, not a single characteristic Devonian fossil having been found in this or any other part of Ireland." Professor Haughton then observes, that "too much importance has been attached to systems and system-makers hitherto in geology; and many of the controversies waged respecting silurian and Devonian groups, have had their origin in, or, at least, owe their continuance to a desire on the part of the controversialists to extend, beyond their due boundaries, merely local subdivisions and names;" but this caution, however applicable it may have been to that stage in geological science, when observers, striving to unravel the tangled web of the earth's mineral history, were naturally led to attach undue importance to each fragment which they had succeeded in reducing to order, is no longer necessary, as our modern geologists are fully aware that they must seek in one country not for the repetition of the strata, bed by bed, of another, but simply for the representative strata deposited simultaneously with them; nor is this all, as they are also fully aware that the alteration of the mineral and physical conditions of the strata must have been attended with a similar variation in the groups of organic beings, or in the relics which they have left of their existence. To determine the age of a drift-deposit must always require peculiar caution, as the organic remains of a previous deposit may so readily have been washed into it; whilst, at the same time, conformability of stratification can in such cases form no sufficient evidence for uniting the upper to the lower, as experience shows us that the drift-deposits of our own coasts would assume a parallelism of position were they thrown up against a sloping bank or bed. It is necessary, therefore, to pass beyond the limits of the drift-deposits, and to make the inquiry in these localities where other deposits indicating a state of tranquillity may from their position be fairly considered as coincident in time with the drift. This is the course pursued by our most able geologists, including Sir Charles Lyell, although Mr. Kelly objects to this *modus operandi*, observing, "This is my view of the Devonian system: had it been composed of a regular succession of rocks, lying together like the Silurian system, or like the Carboniferous formation, there would be no doubt about it; but to make it good, instead of working it out in Devon, its own country, one of the most profound geologists found it necessary to ransack Europe, to get suitable parts to make it up; and it appears to me that Sir Charles Lyell undertook no easy task, when he took a limb from Dura Denn, a joint from the cornstones of Herefordshire, an arm from the green chloritic slates of Cornwall, a leg from the grey sandstones of Cromarty, and a part from the Eifel limestone, and endeavoured to join these distant fragments together and make out of them a consistent whole." Without doubt the task was and is difficult, as that of the correlation of the strata of any epoch in distant countries must necessarily be; but, though difficult, it is the reasonable and proper task of the modern geologist. The yellow sandstone of Dura Denn, Fife, is classed by Sir C. Lyell as the upper member of the Upper Devonian, and is considered also by Mr. Kelly as the equivalent of the upper part of the so-called Irish Old Red; but, as by him this yellow sandstone ought not in Ireland to be separated from the Carboniferous, he concludes that the other subdivisions enumerated by him in the Irish Old Red should also be classed with the Carboniferous formation. To establish a community of fossils, Mr. Kelly quotes a peculiar red sandstone in the Kildress River, county of Tyrone, as yielding many common Mountain-limestone fossils, this sandstone being, in his opinion, near the base of the Old Red in that locality; but it appears to me that this sandstone requires further examination before it can be admitted as a sufficient proof. The brown-stone conglomerate, usually classed with the Old Red, and differing from it in nothing but a more rusty-brown colour, lies indeed conformably on the Tyrone schists with Graptolites, but has hitherto in that locality yielded no fossils of any description: Mr. Kelly, however, considers it identical with other brownstone beds in the South of Ireland which have produced Silurian fossils; but this identification requires further investigation. Now, as these conglomerate-beds, without fossils, of very considerable thickness, follow immediately upon the Silurian rocks, whilst those of the Hook underlie conformably the Carboniferous rocks without producing any of their fossils, excepting indeed in the upper member or the yellow sandstone, which, at least in the limestone-beds alternating with it, does contain such fossils, ought we not to suppose that there is a large gap between them unoccupied probably in Ireland, but in other countries filled up by those shaly and limestone deposits which have yielded fossils characteristic of an intermediate epoch between the Silurian and Carboniferous periods?

The Dublin Geological Journal contains also a paper by Mr. C. H. Kinahan, in which he describes the igneous rocks of the Berehaven district, dividing them into contemporaneous and eruptive traps, and showing their connexion with the old red sandstone and carboniferous formations. I have noticed these papers, forming part only of the labours of the Geological Society of Dublin, in order to show that our sister society is not relaxing in its exertions to promote our science, the establishment of the Government Survey in Ireland having, as in England, in no respect tended to relax or to discourage the zeal of independent observers, but, on the contrary, having excited in them an additional vigour.

I shall now notice the new series of Memoirs of the Geological Survey of India, principally relating to the Talcheer Coal Field, in the province of Cuttack. It is remarkable, as Mr. Oldham states, that for fifteen years the attention of the government in India had been called to the supposed valuable coal-deposits of this district, and specimens were from time to time sent for examination and found worthless, when at length Messrs. W. T. and H. F. Blanford, and Wm. Theobald, jun., of the Geological Survey, were sent to examine the district, determine the limits of the coal-basin, and estimate its value. The district is described as an alluvial plain, extending from the coast to the hills of the district of Cuttack, which are stated to be small and isolated, and so rounded in form as to suggest the idea that the whole of this district had been at no remote period below the sea-level, and raised gradually from the coast inwards. The metamorphic rocks are gneiss and hornblende, and quartz and schists; and the sedimentary rocks are sandstones, conglomerates, and shales, in part carbonaceous, which form two basins, the Talcheer and the Atgurh basins, of which the former is the larger. In descending order they form three groups: 1, Mahadewa group or upper grit series, about 1500 to 2000 feet thick, consisting of unfossiliferous quartzose grits and conglomerates, and coarse sandstones, the conglomerates predominating towards the base of the series; 2, the Damoodah group or carboniferous shales, 1800 feet thick, consisting of blue and black shales, carbonaceous shales, and interstratified sandstones, the group being fossiliferous; 3, the Talcheer group or lower sandstone series, about 550 feet thick and slightly fossiliferous, consisting of blue nodular shale, fine sandstone, and a very remarkable boulder-bed. The boulders in this bed are essentially granitic and gneissose, the granite-boulders being frequently 4 to 5 feet in diameter, imbedded in a matrix sometimes of coarse sandstone, sometimes of the finest shale, and at Parongo of dark-green silt; and the bed itself is very curious, the authors explaining the transport of such boulders by the moving power of ground or floating ice formed and carried down by rivers. In respect to climatal difficulties in such an explanation, the authors point out that the winter temperature of Thibet is between 23° and 41°, although the summer temperature is between 77° and 81° Fahr., this country lying only 10° to 15° north of Cuttack, so that a very small variation in local circumstances would be sufficient to account for the change in temperature from the epoch of this deposit to the present epoch; but, even allowing the force of this reasoning, I am myself almost inclined to prefer the Mallet theory of the mud-slips upon a coast, by which the boulders lodged along a coast-line would be gradually shifted downwards to deep water, and finally imbedded in the mud: in either case it is a very remarkable example of similar causes producing similar effects at all periods of the earth's history. The fossils are the remains of plants, and the strange deficiency of other organic remains through so large a space is justly contrasted with the exuberance of organic life of the existing epoch. The authors put this series in comparison with the deposits of the Nagpur district, described by Messrs. Hislop and Hunter in the Journal of the Geological Society; the general parallelism of the several divisions being strongly marked, both by the mineral character of the beds as well as the organic remains. Mr. Hislop has, however, ascribed the carbonaceous beds of Central India to the Oolites, and the authors advance their reasons for differing from his statement, principally founded upon the supposed position of the Mangali shales of Hislop, which appears to be between the upper and lower members of the series. These shales produced the Labyrinthodontoid Batrachian described by Owen; and, as this group of animals is now found to be characteristic of the Permian as well as of the Triassic deposits, the authors consider it probable that the Talcheer, Damoodah, and other Bengal carbonaceous fields are not more recent than the Permian epoch, whatever may be the apparent testimony of the vegetable evidence.

These deposits being manifestly valueless as coal-bearing strata, Mr. Oldham investigates the circumstances of the iron-ores of Talcheer, and of the manufacture of them into iron. The ores are oxides, either the magnetic or red and brown hæmatites. The fuel used is always charcoal, and the iron produced is of an excellent quality. Mr. Oldham describes the manufacture in detail; and, having ascertained that about 200 tons of charcoal may be produced from a square mile, and that with sundry improvements in the manufacture, 2·5 tons of charcoal will produce 1 ton of wrought iron, he concludes that a circle of forest four miles in diameter would be sufficient to produce 1000 tons of wrought iron, and about 300 square miles would produce fuel for 24,000 tons. All these calculations are worked out with the greatest care and ability, and consequently afford a reasonable basis for establishing the iron-manufacture with a good chance of permanency, provided proper care be taken in the management of the forests.

Notices of the gold of Assam, and of the province of Martaban in Burmah, conclude these memoirs: proceeding, as in every other case, from some one of the metamorphic class of rocks, the gold is obtained as usual by washing, and it does not appear that the yield is sufficient to pay more than a moderate return for the labour. The Assam auriferous deposits are described by Captain E. T. Dalton and Lieut.-Col. J. F. Hannay.

I shall now briefly notice a work on the Coal-formation of Saxony, by Prof. Hanns Bruno Geinitz, the first part of which (Geognost. Darstellung, &c.) has been published under the authority of the Minister of the Interior of that kingdom. It appears in a folio form, and is illustrated by twelve large plates, exhibiting the position of all the existing shafts, the number of seams, and all the accidents of the strata, whether due to faults or the intrusion of igneous rocks; the size being very well fitted for the illustrations, but inconvenient for perusal. The author, whilst enforcing the advantage of affording new means of industry to the inhabitants, by pointing out the extension of the coal-formation in Saxony, on the great principle that the material wants of a population must be satisfied before any great progress can be made in supplying intellectual wants, wisely adds, that hopes of an inexhaustible supply of this precious fuel must not be indulged in. The work commences with a general review of the formations in which coaly matter has been found, commencing with turf, respecting which he observes, that, as the remains of the Giant Deer, *Cervus euryceros*, of the Giant Buffalo, *Bos priscus*, and of the Mammoth, *Elephas primigenius*, have been found in such bogs, it must be assumed that these animals had either died in the historic period during which the alluvium had been deposited, or that the commencement of the growth of the bog must be placed in a period antecedent to the present epoch. The next is the Tertiary or brown coal, some varieties of which approximate so closely to true coal as to have been called Pitch-coal, all organic structure having disappeared. An interesting variety is the Paper-coal of Rott, near Bonn, and of Erpel on the Rhine; it is rich in the remains of fresh-water fish, namely, *Leuciscus papyraceus* (Bronn), and of Frogs, the finest examples of which, to be seen in the Museum of Dresden, have been described by Giebel as *Palæophrygnos grandipes*. When this coal is burnt, the ashes are rich in infusorial remains.

In the cretaceous formation at the base of the Upper Quader at Pirna, a coal-deposit occurs, as also west of Dresden at Erligt, and in other places down to the lowest beds of the Lower Quader. These deposits, rich in leaves and other remains of plants, are not universal through the Quader; and, where they occur in the midst of a marine formation, they manifestly indicate the points where rivers once flowed into the Quader Sea.

The Wealden, Jura, Lias, and Alpine coal are next considered. Sometimes the Wealden coal is very rich in carbon, and it has yielded a supply of excellent coke to the Hanover and Minden, the Berlin and Magdeburg, and the Magdeburg and Halberstadt Railways. As localities of the Jura and Lias coal, Boll in Würtemburg, Seefeld in the

Tyrol, and Walgau in Bavaria are named; and it is said that such formation does not merely consist of the combustible shale which is used for the production of asphalte, but also in many places, as in the north-eastern Alps, of a black shining coal, called by Haidinger "Alpine coal."

The Keuper coal (Lettenkohle) occurs at the upper boundary of the Muschelkalk.

In the Permian strata of Saxony, a coal-deposit occurs, which was considered to belong to the coal-formation until Von Gutbier pointed out that the remains of plants which it contains were specifically distinct from those of the true coal-formation. The "Brandschiefer," previously described by Naumann, has yielded *Lycopodites piniformis*, Schlotheim, and *Walchia filiciformis*, Schlotheim, amongst vegetables; and of fishes, species of the genera *Amblypterus*, *Holocanthodes*, *Xenacanthus*, and *Cephalaspis*, together with the thin shells of a *Cypris*, which much resembles the *Posidonomya minuta*.

Coming now to the true coal-formation, M. Geinitz describes all the varieties from a pitch-coal up to the "Stangenkohle," a natural coke; observing, that anthracite must in most cases be considered an altered coal; and, taking the organic contents rather than the mineral condition as the basis of arrangement, he recognizes the following varieties in the Saxon coal, though not separated from each other by a strongly marked line; namely,—1. The Sigillaria-coal, consisting of thin beds of bituminous pitch-coal. 2. Calamite-coal, containing *Calamites cannæformis*, Schloth., *C. Suckowii*, Brong., and *C. approximatus*, Schloth.; as well as *Asterophyllites* and *Sphenophyllum*. 3. Fern-coal, thin-bedded and very bituminous. 4. Nœggerathia-coal, a meagre, hard, slaty coal, in which occur *Nœggerathia palmæformis*, Göppert, and *N. crassa*, Göppert. 5. Sagenaria-coal, a bituminous slaty coal. The culm-measures of Devonshire and Pembrokeshire are considered, with the mountain-limestone, to be the equivalent of what in Germany is still called the "younger grauwacke." The Sagenaria-coal above mentioned belongs to this division; and, as the mountain-limestone is deficient, Geinitz considers that this coal, which differs so strongly in its organic contents from that of Zwickau, and occurs in the Hainich-Ebersdorf coal-field, must be considered as the Saxon equivalent of the mountain-limestone, and be therefore classed with this division.

Certain layers of coal in Saxony may be supposed to belong to the devonian formation; but, as the strata have suffered much from the disturbance and metamorphic actions of igneous rocks, some doubts may exist as to their true position: in other countries, however, the authority of De Verneuil is quoted for the probable Devonian age of the rich coal-deposits of Sabeso between Oviedo and Leon, the fossils of the strata associated with the coal being of Devonian age, and that of Keyserling for the "Brandschiefer" of Northern Russia.

In the Silurian strata, though carbonaceous matter and alum-slates may be found, no true coal can be expected, as hitherto but little evidence of the existence of a land- or coast-flora has been discovered.

Graphite, or crystallized carbon occurs, as is well known, in gneiss, mica-slate, and other metamorphic rocks. The occurrence of fragments of wood or other coal in igneous rocks depends of course upon other circumstances, and has no bearing upon the question of the age of such fragments.

This sketch of the history of fossil carbon is so interesting, that I have dwelt upon it longer than I intended; and I shall therefore compress into a small space any further remarks upon this work. The great divisions of the Saxon coal-field may now be stated as follows:—

1. The coal-formation of Hainich-Ebersdorf, which is the earliest band of vegetation in Saxony. 2. The Sigillaria-coal, in which the remains of such plants greatly predominate over all others; this coal is the lowest bed of the Zwickau basin. 3. The Calamite-coal, in which a forest of Calamites, including some of the largest known species, appears to have been buried; mixed, of course, with species of other genera. 4. The next zone also is rich in Calamites, though not in the same proportion as in the one below; the *Calamites approximatus* being, however, most abundant. The *Annularia longifolia* finds its peculiar horizon here, in which it appears to have attained its highest development, though found both in lower and higher beds. 5. The last girdle or zone of vegetation is characterized by an abundance of Ferns, since of ninety-eight species of plants, fifty belong to this family of plants.

The 5th zone has eighteen species in common with the 4th, the same number with the 3rd, and even somewhat more with the 2nd; but, as Geinitz observes, it is not so much the relative number of species, here so striking, which gives a peculiar character to the flora, as the number of individuals, which must also materially affect the nature of the coal.

The coal-formation of Zwickau rests on strata which are considered Devonian, and under these occur strata which are supposed to belong to the upper portion of the lower Silurian, being rich in Graptolites. The upper Silurian is, according to Geinitz, wanting in Saxony.

The plants from which the coal was formed lived during a period of rest; but, when the igneous rocks began to uplift the crust, cracks were formed, heated steam arose, and in its passage through the carboniferous deposits reduced some of them to mud, and then, being condensed, poured down in heavy rain, by which dislocated fragments of plutonic and metamorphic rocks were, with the slime, formed into the grey conglomerate which now overlies the coal-deposits of Zwickau, and is placed by Geinitz in the Permian formation. This is a curious view of the mode of formation, and is illustrated in the sections of the coal-deposits of Zwickau by several flows, as it were, of the pulverized muddy matter through the broken strata. I shall not further extend my remarks on this most interesting work, which leaves nothing unnoticed, describing each important locality and every form of rock; and I shall conclude with a brief summary of the fossils as given in a tabular form. No figures of fossils accompany this part of the work. Of fishes, *Lamna carbonaria*, Germar, and a Fish-coprolite are the only remains; of boring insects there are traces in the *Sigillariæ* and *Calamites*; of worms, the *Gordius carbonarius*, Geinitz; of mollusca, 5 species; and of infusoria 4. Of the 14 species thus enumerated, only 6 extend beyond the Saxon deposits. Of plants, 156 species are named, of which 46 are common to the Saxon and British Coal-formations. Many of these are again common to the British and American coal, whilst others are not in the British, though common to the Saxon and American deposits. With, therefore, sufficient elements for connecting the various local deposits into one great whole, there are yet many and striking proofs of local peculiarity.

In respect to the five bands or zones of successive vegetable life:—the 1st has only one species out of 23 common to it and the second and third, so that the separation of the so-called culm-formation is very marked; between the 2nd and 3rd there are 33 species common, or 32·35 per cent.; between the 3rd and 4th, 28 or 23·73 per cent.; between the 2nd and 5th, 33, or 20·12 per cent.; between the 3rd and 4th, 24, or 25·59 per cent.; the 3rd and 5th, 33, or 23·57 per cent.; and the 4th and 5th, 35, or 22·43: and it is remarkable that, whilst the progression from the 2nd to the 5th is gradual and uniform, the relation between the 3rd and 5th, and 4th and 5th, are nearly the same. Only three plants pass upwards into the Permian, so that the coal-deposits are as abruptly separated from the Rothliegendes above, as from the culm-formation below; an interesting proof of the value of the evidence thus afforded by plants.

The Zwickau coal consists of nine beds, amounting together to about 80 feet, the greatest being 25 feet thick, and at a depth of 480 feet from the surface; the total thickness of the deposits is 580 feet.

Of the Permian strata Professor King has extended the limits from the well-known locality at Cultra, on the bank of Belfast Lough, to Ardtrea, in the county of Tyrone. The peculiarity of the small limestone-deposit, thus abstracted from the overlying new red sandstone was not unnoticed by myself and by my then assistant, Mr. Oldham, and I specially marked it out in my Report as requiring further examination. At that time the fossils of the Permian system were not so well known as at present, and, as I had then no power of going beyond the district and seeking an illustration of the true position of this rock elsewhere, I was obliged to content myself by pointing out its uncertain character. The recognition of the Permian character of the Ardtrea limestone is given in the Journal of the Geological Society of Dublin; and Professor King has also published in the "Annals of Natural History," two short papers, in which he describes a new species of *Productus, P. Schaurothianus,* found by himself in some Zechstein from Germany, and passes in review the descriptions and determinations of others, most of which had been recorded in his Monograph, discussing several interesting questions regarding their structure. Of 45 species of Palliobranchiata, noticed in his list, 22 are common to the German and English formations; 9 are common to the German and Russian, and only 5 common to the German, Russian, and English; numbers which certainly suggest much matter for reflection, when it is remembered that Russia may be regarded as the typical country of the formation. In noticing this paper, and alluding also to that by Mr. Binney, I may observe that much of the extension of the Permian has been obtained by the abstraction of portions of strata formerly allotted to the New Red Sandstone; and that, whilst the continuance and still powerful development of the genera *Productus* and *Spirifer* approximates the Permian closely to the Carboniferous system, it may be added, that the mineral connexion is also striking, as magnesian limestone occurs extensively in the carboniferous limestone; for example, as a member of the carboniferous series at the Hook, and again near Cork, where it has given rise to a flourishing manufacture of carbonate of magnesia.

In respect to papers bearing on the physical forces which act upon the earth's crust, I may notice a brief communication in the Philosophical Magazine, by Professor Hennessy, of the Catholic University of Ireland, on the Influence of the Earth's Internal Structure on the Length of the Day. He adopts the theory of a solidified crust having a still fluid nucleus within it; and, rejecting Poisson's view of cooling from the centre to the surface, he assumes that the crust, in passing through the vitreous to the crystalline condition, has contracted within itself, so as to leave a space between it and the nucleus, or, in other words, so as to diminish the pressure upon that nucleus, which would of course then expand and fill up the space with a semi-fluid body of a diminished density: the cooling then proceeding, new layers would be added to the interior of the crust, which, contracting by crystallization, would again remove the pressure on the nucleus, and lead again to its expansion. Mr. W. Hopkins had before proved, from astronomical considerations, that the crust and nucleus must move together nearly as if they formed one body, and Prof. Hennessy adds, that there must be great friction between the nucleus and the interior of the crust, which should be taken into account when considering the effect which would follow any sudden fracture of the crust. This distinction between a contraction of the crust within itself from crystallization, and the general or cubical contraction of the whole mass on cooling, leads to a difference between the deductions of Professor Hennessy and those of M. Delesse, who concludes that the whole diameter of the earth would be diminished, and the velocity of rotation increased; whereas, by the removal, as it were, of the matter from the centre to the surface by its crystallization and adherence to the inner surface of the earth, the moments of inertia would be augmented, and the length of the day increased. Mr. Hennessy considers that the contraction of the general mass is in this way counterbalanced, and that the length of the day remains, and will for ages remain, palpably unaltered.

These glimpses at the internal condition of the earth are interesting and important as regards the operations of igneous rocks; but, however ingenious the reasonings upon the subject may be, the data are as yet too speculative to admit of any positive certainty in the geological deductions dependent upon them.

The recent operations of the National Survey in Scotland have also an interesting bearing on the condition of the earth's crust, and I feel bound therefore to notice them in order to testify my gratitude to Col. James for having extended the labours of his department beyond the ordinary investigations of a survey, so as to embrace the interesting question of the earth's density, and my high appreciation of the ability of Capt. Clarke, R.E., who has made all the necessary calculations required for the very intricate discussion of the results obtained. It has long been a recognized fact that the plumb-line of an instrument used for obtaining the altitudes of celestial objects is often so deflected by local attractions, as to produce a material disagreement between astronomical and geodetical amplitudes. Lieut.-Col. Yolland, under the direction of the late General Colby, had investigated the circumstances of such attractions in respect to some of the leading points of the Trigonometrical Survey, but Col. James has gone further in Scotland, by taking advantage of the contoured plans of the county of Edinburgh, and the known specific gravity of the rocks, in order to determine the amount of local attraction which would be exercised on the zenith sector placed upon Arthur's Seat, near Edinburgh, and in what degree that attraction would account for the deflection of 5″·25 at Arthur's Seat; or of the 5″·63 at the Royal Observatory on Calton Hill.

The unequal distribution of matter, the great trough of the Frith of Forth being on the north and the range of the Pentland Hills to the south, affords a presumptive reason for such deflection, and in consequence observations were taken both at Arthur's Seat, and at points near the meridian, on the north and south of that mountain, the observation-duty having been confided to Sergeant-Major Steel of the Royal Sappers and Miners, who performed it with great ability.

After some preliminary investigations, Capt. Clarke states that the geodetical amplitudes between the station on Arthur's Seat and those north and south of it having been determined geodetically by a subsidiary triangulation, the differences between the astronomical and geodetical amplitudes were as follows:—

Between the vertex of the Hill and South Station	A + G. . 2″·81.
Between the vertex and North Station	A + G. . 1″·26.
Between the North and South Stations	A + G. . 4″·07.

Comparing now the geodetical and astronomical latitudes, the astronomical exceeds the geodetical at the Vertex 5″·25, at South Station 2″·44, at North Station 6″·51; and Capt. Clarke observes that these deflections cannot be accounted for by the attraction of Arthur's Seat alone, as such attraction ought to have operated at the South Station in an opposite direction, should have been *nil* at the Vertex, and could not have produced so great a result as that of the North Station. The comparison of the observed and geodetical latitudes of Calton Hill gives similar results, as the deflection to the South is 5″·63, of which not more than 0″·1 or 0″·3 can be ascribed to the attraction of Arthur's Seat. Capt. Clarke then shows that the deficiency of matter in the hollow of the Forth would be insufficient to account for the deflection, as the attraction of the mass of water would be about 0″·02, and that of a mass of rock of spec. grav. 2·5 filling up the Forth, to the level of 150 feet, $0''\cdot50$: the great deflection therefore of $5''$ must be accounted for by some other source of attraction, namely, the Pentland Hills; and Capt. Clarke's conclusions, who has made all the necessary calculations required for the very intricate discussion of the results obtained, are, 1st, That the attraction of the Pentland Hills is nearly equal at each of three Stations on Arthur's Seat. 2nd, That the deflection at each of the three Stations, due to the attraction of Arthur's Seat, is at South Station $2''\cdot21$ North; at Vertex $0''\cdot37$ South; at North Station $2''\cdot00$ South; and that the remaining $4''\cdot88$ of deflection is due to the attraction of the Pentland Hills. 3rd, Of the $4''\cdot88$ of deflection $2''\cdot5$ may be considered due to the attraction of the ground within a radius of 15 miles, and that the difference between the observed and computed attraction may be due to the high specific gravity of the mass of rock beneath Arthur's Seat and the Pentland Hills;—I may indeed observe that $2''\cdot5$ appears a rather low specific gravity for igneous rocks of a basaltic type. 4th, That the latitude of Arthur's Seat varies $0''\cdot02$ from the difference of attraction consequent on the change of level from low to high water. 5th, That the mean density of the earth as deduced from these calculations is $5''\cdot316$; being above that deduced from the Schehallien experiments, or $5''\cdot0$, and below that obtained by other experiments, the late pendulum-observations of the Astronomer Royal having carried it as high as $6''\cdot57$.

It appears to me right to notice here the very interesting researches made by the Coast Survey of the United States, and published under the authority of the Government in the American Journal of Science by Professor A. D. Bache, Superintendent of that Survey, which relate to the distribution of temperature in and near the Gulf-stream, the results being exhibited in diagrams by the system of curves. The first of these represents the varying temperature with depth; and, though the rate of diminution cannot be thoroughly understood without inspection of the diagram, I may state that at the surface the temperature is 82°, and at 700 fathoms 38°. Several other diagrams represent the temperature at the same depth, in sections across the Gulf-stream, and exhibit some remarkable phænomena; namely,—1st, that the Gulf-stream is limited laterally by cold water, the passage from one to the other being so abrupt, that the boundary of cold water has been called "The Cold Wall." 2nd, That there is a considerable oscillation up and down of the lines of equal temperature; and that, as these variations are permanent, having been observed in several successive seasons, the Gulf-stream appears to be divided into several bands, with intermediate streaks of colder water.

The section through the Gulf-stream, off Charleston, is the most illustrative of these facts; and, as this section is almost entirely within soundings, it illustrates another curious fact, namely, that the oscillations of the lines of equal temperature appear to be influenced by the form of the bottom. Thus, for example, the bottom slopes gradually for fifty miles, reaching a depth of about 20 fathoms; then more rapidly for sixty-five, to a depth of 100 fathoms, when it suddenly falls to a depth of more than 600 fathoms. At 100 miles the depth is only 300 fathoms, so that a ridge rises here with a slope very steep on the inshore side and a little less seaward; this ridge is 1500 feet above a hollow seaward of it, and twelve miles distant; in another twelve miles there is again a rise of 500 feet, on a base of twelve miles, which is followed by a depression of 300 feet on a base of fifteen miles, and then by a gentle slope upwards with only very moderate variations. The lines of equal temperature follow these bends in the sea-bottom, the line of 57° of temperature sinking down in the deep hollow before noticed to a depth of 600 fathoms, and rising up over the ridge to the depth of 220 fathoms. These variations are curious, as they show that the cold water does not maintain a level surface, but follows the inequalities of the sea-bottom, lifting up or lowering down the warm Gulf-stream above it; and it is easy to perceive how the progression of animal life may be affected by such circumstances. In this section, the temperature at 175 nautical miles is 77°, which does not descend lower than 20 or 25 fathoms; the temperature of 72° to about 75 fathoms; that of 67° to 200; and of 62° to 300 fathoms; these several zones stretching out in a similar manner laterally.

Mr. Poole, on behalf of the Government, visited the Dead Sea, and the Society has to thank the Foreign Office for communicating in this and in many other cases the information obtained. The object of Mr. Poole was to ascertain whether nitre could be obtained, as reported, in large quantities, but he found none, common salt having been apparently confounded with it from a similarity in the Arabic names for the two salts; sulphur, sulphurous earths, and common salt are the products of the district. Several reports on the Eruption of Mauna Loa in Hawaii came to us from Consul-general Miller, also through the Foreign Office. This eruption was remarkable for the height of the mountain, 14,000 feet; for the time during which the current of lava continued to flow, about three months; for the distance over which it passed, fifty miles; and from the fact that the lava flowed underground for a considerable distance.

From Mr. Babbage we have had an ingenious explanation of the manner in which the detritic matter carried down by streams is distributed in the ocean, being carried forward by the velocity acquired by the river-water in its descent upon land and drawn downward by gravity, but slowly, in consequence of the resistance of the medium. The action of currents modifies the direction of the moving matter, which in this way forms a film or plane of mud or other detritus, gradually sinking downwards, and, in Mr. Babbage's opinion, occasionally capping the rocks below and producing the appearance of outliers. Without doubt the descent of detritus must be conducted in something like the manner here described, subject to the disturbing action of storms and currents; it was Mr. Babbage's object to trace the progress of the descent, and to speculate upon the consequent formation of strata, which he has done with his usual ingenuity.

After an interval of thirty years, Mr. Poulett Scrope has again brought before geologists his views on the formation of craters and on the nature of the liquidity of lava; but under what different circumstances does he now advance his opinion? The theory of craters of elevation was at the time of his first writing in its zenith, as every one seemed to follow the guidance of Von Buch, and it appeared, as is often the case, almost a duty to resist as a lawless intruder every one who differed from that theory. In commenting on the life of Constant Prévost, I have shown how he, after a lapse of many years, had found it necessary to abandon the standard of Von Buch; and it may be fairly stated, that the great majority of modern geologists now hold the opinions which Mr. Scrope advocated with so little success more than a quarter of a century ago. All, however, have not abandoned the theory of a crater of elevation; many are still inclined to ascribe a larger share in the formation of a volcanic mountain to the elevatory process, than would be the result of simple fracture by explosive aëriform eruptions, though they are quite ready to admit that the subsequent eruptions have, by successive accumulations of lava and other matters, materially, nay principally conducted to the present result. I hope to be able to recur to this subject again; at present I will only congratulate Mr. Scrope on having so completely outlived the prejudices which were at first so strenuously opposed to his theory of craters as well as to his view of the semi-liquidity of lava.

Mr. James Gay Sawkins visited, in 1854, the Island of Tongataboo, one of the Friendly Islands, which had been recently visited by an earthquake, and found that the north-east portion had been tilted down so as to cause an encroachment of the sea for two miles inland, and the western coast had risen some feet. The island is formed of coral, and some parts of it are 116 feet high. This earthquake is said to have led to the appearance of an island to the west of Tongataboo, and was followed by an eruption at an island to the north. Mr. Sawkins is of opinion, that upheaval predominates over subsidence in the Pacific, and mentions the occurrence at Tahiti, one of the Society Islands, of alternate layers, upon highly elevated ground, of coral and volcanic lava, so that there must have been time for the growth of the coral before and after each eruption previous to the final elevation of the island.

In respect to papers on minerals, Dr. Rubidge has described the geology of Namaqualand and the bordering countries, and explained the manner in which the copper is found, namely, in fissures of the gneiss, which is disturbed parallel to the strike; it also occurs in crevices of the rock without any veinstone or gangue. The ores are principally the oxides and silicates; and the appearances, from the mode of distribution being sometimes deceptive, have led adventurers to imagine that they have found a mountain of copper ore. Mr. Dick has given us an analysis of the iron-ore from the Middle Lias of Yorkshire. The Rev. R. H. Cobbold has announced the existence of a bright but not bituminous coal near the city of E-u in China; this information coming to us through the Earl of Clarendon as Foreign Minister. The Rev. W. S. Symonds pointed out the analogy between the effects of the great Malvern Bonfire on the syenite forming the platform on which the fire rested, and that of trap and greenstone dykes upon the same rock in a neighbouring quarry.

Mr. J. S. Wilson, Geologist to the North Australian Expedition, has contributed a brief notice of the coal-formation of the neighbourhood of Sydney. The sandstones and shales associated with the coal resemble those of England, and the coal-shales abound in leaves of plants, with much bituminous matter. There are two seams of coal, the shale covering the upper seam being overlaid by a trap-conglomerate; a trap-dyke, 9 feet thick, cutting through the whole at Nobby's Island. Mr. Wilson mentions two examples of fossil forests, the first resting upon a bed of shale generally covered at high water, the roots and stems having been fossilized so as to become a rich ironstone. In one locality of the shale Mr. Wilson states the discovery of fine specimens of *Lepidodendron*. Amongst many other remarks upon the igneous rocks and metamorphic rocks, Mr. Wilson doubts the accuracy of the statement of Mr. Odernheimer, that "dioritic and syenitic rocks are, in the gold-fields of the Peel, the exclusive bearers of the gold-quartz-veins," as being opposed to his own experience in other respects.

Mr. S. H. Beckles has described a cliff-section from Hastings to Cliffend. The strata noticed form two remarkable bands, the upper consisting of shale and associated ironstone, which had been described by Mr. Webster (his description, however, requiring some modification), and the lower of sandstone with several layers of clay of various intensity of colour. These bands undulate in the cliff, sometimes rising on its face to the height of 20 feet, and then sinking down below the water-level. All the organic remains indicate deposition in fresh water. The shale with ironstone at the top contains *Cyrenæ*, *Unionidæ*, Insects (as before stated by Messrs. Binfield), and bones of Saurians, whilst the ironstone itself abounds with vegetable remains. The sandstone contains small varieties of *Unio* and casts of footprints, whilst the layer of clay immediately below it affords very fine specimens of a *Zamia*, and of two other plants, together with a large *Anodon*?, a small *Paludina*?, and some small coprolitic bodies of rare occurrence. The lower layer of clay is not rich in fossils, but the discovery of the dorsal rays of *Hybodus* justifies Mr. Beckles in hoping for further discovery with a more extensive examination. These beds constitute the lowest visible members of the Wealden at Hastings.

Several short papers of a miscellaneous character were also contributed, each communicating some isolated fact; such, for example, as that by Mr. Bunbury, of a deposit of black peaty mud 20 feet thick, formed at the bottom of a mere near Wretham Hall, Norfolk. This mud is vegetable matter in a more complete state of decomposition than ordinary peat, and imbedded in it is an horizontal layer of compressed but undecayed moss, from 2 to 6 inches thick, the moss being the common *Hypnum fluitans*. The peat above and below the moss-band is precisely the same; numerous horns of red-deer are found in the peat at a depth of 5 or 6 feet, some having been cut apparently with a saw; seams of sand occur, and occasionally flints and fragments of quartz, the gravel of the country; trunks of trees, probably the birch and oak, and oak-posts, shaped, pointed, and standing erect, were also found. Mr. Bunbury concludes from the state of the moss, that aquatic mosses are not rapidly destroyed by moisture, and that the want of mosses in former geological periods must be explained upon some other principle. The moss-bed is presumed to have been formed at least some centuries ago.

An analysis, by Dr. Richardson and Mr. Browell, of mineral waters brought from the borders of Persia by Mr. W. K. Loftus, proved that these waters are more or less rich in carbonate of soda. A notice by Mr. J. Wolley of an ice-carried boulder at Borgholm, 10 feet long, 7 broad, and 6 thick, affords an interesting recent example of the transporting action of coast-ice. Mr. Cleghorn contributed a paper on the origin of the potholes which are observed on the surface of the granitic rocks of Cornwall, now raised many hundred feet above the sea-level, and which are ascribed by him to the former action of the sea, when beating upon them as part of the coast; other writers have considered them as one of the results of glacial action; either explanation being perhaps preferable to the more ancient one, which supposed them all to have been formed by the agency of man. A sketch of the geology of Trinidad was given by Mr. H. G. Bowen. In the north, unfossiliferous slates, flagstones, and limestones occur; and some of the ochreous quartz-veins are slightly auriferous. Alluvial beds, 60 feet thick, are extensive in this district. In the south, sandstones, variegated sands, lignitiferous clays (sometimes jasperized), and the Moruga limestone form the base; blue and brown clays with bitumen, comprising the pitch lakes, salt and alum springs, &c. succeed; then a modern marine sand formation, from 50 to 100 feet thick; and lastly alluvial deposits, seldom more than 30 feet thick.

Mr. H. J. Moyle, through Consul-general Hillier, forwarded a notice of the occurrence in Siam of various metalliferous ores, principally cupreous; this being another contribution from the Foreign Office. The Rev. W. B. Clarke has furnished a note on volcanic bombs in the alluvial drift of Victoria and Tasmania.

Mr. Morris announced the discovery of Allophane at Charlton, Kent, in the fissures of the chalk; a substance, which occurs under similar conditions in the chalk of Beauvais in France, and in other rocks in Thuringia and Saxony. Mr. Morris suggests that the hydrated silicate of alumina may have been formed by the filtration of atmospheric waters through the superficial deposits. In the case of stalactitic hydrates, the decomposition of the minerals of the rocks puts their elementary constituents in a fit condition to be thus carried away by water; and it is not improbable that such decomposition may be still proceeding in certain clay and sand deposits, with similar results.

It has been frequently remarked, as a source of regret, that small isolated papers, such as the preceding, should now form so large a proportion of our contributions, long papers embracing a large extent of country being comparatively rare; but I think this complaint is unreasonable, as we can scarcely expect that long papers should be now written except upon entirely new localities; and that smaller papers fitted to fill up gaps in preceding descriptions, or to modify and amplify some of the details upon which they were founded, should now be more current. It is the result of the approximation to perfection in our science.

We have had from Professor Owen, several papers during this session, all tending to fill up the gaps in our knowledge of the vertebrated animals of the ancient epochs of the world, or to complete the history of those already known. The *Stereognathus Ooliticus* had been before named and described by Charlesworth; and from the fragment of a lower jaw obtained from the Stonesfield slate by the Rev. J. Dennis, and previously noticed at the British Association in August last, Professor Owen was enabled to determine that the animal is most probably a diminutive non-ruminant Artiodactyle, of carnivorous habits; its nearest allied forms not being existing types, but rather the Hyracotherium, Microtherium, and Hyopotamus of the Tertiary deposits. He then explained the reasoning process, by which such determinations were deduced from so small a fragment; the mammalian character being determined by the two-fanged implantation of the teeth, and the pachydermatous affinities by the peculiar sexcuspidate and cingulated molars, such structural peculiarities having been before ascertained to exist in certain known Pachydermata. In this case the Professor determined the natural position of the animal by morphological resemblances or by structure, not by physiological considerations or functional adaptation; but the Professor observes, that, though the palæontologist must depend more frequently on the morphological than on the physiological basis of reasoning in determining the affinities of an animal, the physiological relations of which he must so often be ignorant of, yet in many cases the analysis may be safely made, from the manifest functional adaptation of the organ examined. Let me add, that in any case, the result, in a philosophical sense, must be imperfect until the physiological relations have been discovered; for until then, the animal must be considered a mass of dead bones, like a crystal or other object of definite form, but not an active member of the universe, destined to play its own part in the scheme of animal existences.

In another paper Professor Owen gives the detailed examination of the tibia of the large fossil bird, from the Lower Eocene of Meudon near Paris, named by Hébert *Gastornis Parisiensis*. Having carefully compared this bone with the corresponding bone in *Dinornis*, *Notornis*, and the nearest related Orders of living birds, Professor Owen concludes that the *Gastornis* was about the size of the Ostrich, but comparatively slenderer, and that its nearest affinities are with the Waders, and most probably with the Rallidæ, but that the genus is manifestly distinct from any living genus. Here again, in a determination founded on morphological considerations, the important fact to the student of the world's history is, that the bird was physiologically a gigantic wader.

Professor Owen next described a collection of mammalian fossils from the Red Crag of Suffolk, including the *Rhinoceros*, of which he considers the species closely allied to, if not identical with *Rh. megarhinus* of the Older Pliocene, or *Rh. Schleiermacheri* of the Miocene, two species of the genus *Sus*, both Miocene, a *Tapirus*, an *Equus*, a *Mastodon*, supposed to be *M. angustidens*, a *Dicranoceros* and a *Megaceros*, a *Felis*, a *Canis*, an *Ursus*, and *Cetacea*, Professor Owen stating that the majority of the specimens are closely allied to, if not identical with, Miocene species.

The determination of a large Serpent, from Capt. Spratt's collection of Greek freshwater tertiaries, of the size of a large rattle-snake, and probably venomous, was also interesting; Professor Owen remarking that, though the mythological history of the Greeks had given creation to snakes of great magnitude, none such are known in the existing fauna of Europe.

Every one is now aware that much difference of opinion has lately arisen respecting the classification of the lower portion of the palæozoic rocks, some being disposed to allot the lower portion of the Silurian series to the Cambrian formation, and others maintaining that the fauna of the lower Silurian and the fauna of the upper Silurian form one complete whole, being far too intimately connected with each other to admit of separation. The advocates of the former opinion appeal to the evidence of foreign countries, and endeavour to prove that, taking into account their fossils, the difference becomes too great for the maintenance of unity; whilst their opponents maintain that we must look at the British succession of strata by itself, and, from the amount of analogy there observed between the upper and lower Silurian, conclude that they form but one system; and then make similar comparisons for other countries; or, in other words, that we must expect to find co-existing and therefore representative, not identical, faunæ. This truth, for it is assuredly one, I have before alluded to; and, when we consider the great difficulty of determining the rate, extent, and direction of the expansion of species from their first centres of creation, we may well admit that there is a question before us worthy of patient and calm discussion. Below the most ancient rocks known to be fossiliferous an immense thickness of flaggy and slaty beds occur in Wales, which have hitherto been considered unfossiliferous or azoic, but Mr. Salter has produced proofs that even here organic life had commenced. In the nearly unaltered sandstone-beds on the eastern side of the Longmynd he discovered traces of Annelides and fragments of a Trilobite, and in the grits near Bangor a supposed Fucoid. The Annelides he refers to *Arenicola didyma*, and he has given the name of *Palæopyge Ramsayi* to the Trilobite, which he considers allied to the *Deikelocephalus* of D. Owen. He also deduces from the surface- or ripple-markings of the flags, a proof that the conditions of sea and land at this remote epoch were very analogous to those now observable, though in this case the ancient shore-deposits have been thrown into a vertical position. For correct specific determination the specimens are probably too imperfect, but they may at least be received as curious indications of the actions going on anterior to the Silurian deposits; whilst the presence of a Trilobite appears to show what could not have been inferred from the

Irish *Olhamia*,—that the characteristic type of organization of the Silurian epoch had already manifested itself.

Mr. Salter also proposed to form a new genus for that remarkable form of Cephalopoda described by Sowerby as *Orthoceras bisiphonatum*, and figured in the "Silurian System," and in "Siluria." In this form ordinary septa are pierced by an excentric-beaded siphuncle, alongside of which a deep lateral cavity passes down, affecting at least seven, if not more, of the septa. Though the character of the shell may be elucidated by the structural peculiarities of *Orthoceras paradoxicum*, and of *Gonioceras*, its real affinities are, in Mr. Salter's opinion, with *Ascoceras* and *Cameroceras*. So great a peculiarity of structure appears to justify the formation of a new genus, although the object of the lateral cavity has not been satisfactorily explained: Mr. Salter has, therefore, called it *Diploceras*. Mr. Salter noticed also a new species of *Ascoceras* from Ludlow, under the name of *A. Barrandii*, the genus itself being new to Britain.

Mr. Salter and Mr. W. H. Baily gave a list of the fossils found in the chalk-flints and greensand of Aberdeenshire, notices of which have been already published in other journals. The fossils are those characteristic of the upper greensand, but the *Lima elegans* of Nilsson, found, in association with the ordinary *Inocerami* and *Echinites* of the chalk, in the rolled flints which form terraces round the hills in Aberdeenshire, is new to Britain, and affords therefore some reason for suggesting a former continuity of these beds with those of the south of Sweden. In Ireland I have shown that the basalt in one locality rests upon a bed of flints, which is there the only representative of the cretaceous formation; but so great must be the difficulty of deducing any certain result from materials which have undergone so much wear as these flints, that I should hesitate to draw so large a conclusion as the former continuity of the Scotch and Swedish beds, though I should come to another, perhaps equally important, namely that the climatal and other conditions of the Scotch and Swedish areas were at the cretaceous epoch so similar as to produce a close resemblance between their respective faunæ.

Mr. J. W. Kirkby, in a communication made through Mr. Davidson, notices the occurrence of a minute Malacostracous Crustacean in the magnesian limestone of Durham. It appears to be the same as the *Trilobites problematicus* of Schlotheim, and *Palæocrangon problematica* of Schauroth; but, in the opinion of Mr. C. Bates, it is nearly related to the Isopoda, and represents their immature rather than their mature form. Every recognition of a recent type of structure in these ancient rocks is of interest, as tending to break down the abrupt organic barrier, supposed, most probably with little reason, to separate geological formations. Amongst the other fossils noticed, was a new species of *Chiton*, *C. Howsianus*.

Mr. S. P. Woodward described the appearance of some *Orthocerata* as exhibited in polished slabs of limestone brought by Mr. Lockhart, from Shanghae, in China, but supposed to have been brought from some place 200 miles distant, where they appear to have been used as screens, having been mounted in wooden frames.

The fossils are supposed to have been of Devonian age, and Mr. Woodward explains the manner in which the mud surrounding the shell had entered into some of the chambers, in which the siphuncle was incomplete; how water, charged with carbonate of lime in solution, had filtrated into others, either lining them with a calcareous tufa, or filling them with a crystalline limestone; and that in others, the calcareous lining not having been complete, the mud, on the dissolution of the external shell, had penetrated and filled up the vacuity. Mr. Woodward also pointed out certain appearances tending to show a gradual separation and collapse of the lining membrane of the air-chambers towards the apex during the lifetime of the animal; and concluded with some remarks on the structure and filling up of the siphuncle in *Actinoceras* and other allied forms of *Cephalopoda*. Doubtless these ingenious remarks of Mr. Woodward will recall to the mind of many, the former labours, and particularly the verbal expositions, of the late Charles Stokes, who devoted so much of his attention to the elucidation of the *Orthocerata*.

Mr. Binney brought under the notice of the Society the supposed foot-prints in the millstone-grit of Tintwistle, Cheshire. The impressions are five in number, the two longest measuring 13 inches in length at the bottom, and 17 inches at the top, with a breadth of 4 and $3\frac{1}{2}$ inches at the bottom, and 8 and 9 inches above, and a depth of 3 inches. The distance between the impressions is $2' \, 10''\frac{1}{2}$, and there is some little difference in shape, arising apparently from the accidental casualties of an animal moving on wet sand. Supposing the impressions to have been made by the same kind of animal which produced those on the Permian sandstone of Corncockle, though they are much larger than those of *Chelichnus Titan* of Jardine, Mr. Binney proposes the name of *C. ingens*.

Mr. Rupert Jones, in a very interesting appendix to a paper by the Rev. P. B. Brodie, on the Upper Keuper Sandstone of Warwickshire, makes a very important rectification of fossil organic nomenclature, by showing that some of the minute species of *Posidonomya* should be removed from the Molluscs, and classed with the bivalved phyllopodous Crustacea (*Entomostraca*), their nearest analogue being found in the genus *Estheria* of Rüppell and Baird. The great abundance of individuals in the species which has given rise to these observations, the *Posidonomya minuta*, or *Estheria minuta* of Jones, in the Trias of Europe, renders it characteristic of the deposits of that geological epoch, and an index therefore to their occurrence in other countries. With this view of the importance of the fossil, and taking into account the association, in some cases, of labyrinthodont and other reptilian forms with this *Estheria*, and in others that of the *Estheria* with sandstones and shales connected with the flora of certain epochs, Mr. Jones justly observes that it may be used in determining in some doubtful cases, such as those of Central India, and of Virginia, whether the deposits ought to be classed with the Triassic or with the Jurassic, or be considered a transition-group between them. The recent *Estheria* is marine; but, as closely-allied forms are of freshwater habits, and as some species of the same genus are marine, and others are freshwater, and as some Entomostracans even live occasionally in one or the other medium, no certain evidence can be drawn from the fossil alone as to whether the Triassic deposits were those of rivers, of lakes, or of seas; but, taking the association of fossils into account, Mr. Jones seems justified in suggesting, on reference to the plant-beds of Nagpur and Virginia, that "these plant-beds with reptiles and crustaceans may indicate the terrestrial and lacustrine conditions only of the early secondary periods." Mr. Brodie had pointed out (from footmarks) in his paper the existence of a Labyrinthodont animal, had noticed the presence of bones, teeth, and spines of *Acrodus*, with other small teeth and scales, and recorded the existence of plants, and then, remarking upon the abundance of the *Posidonomya*, he justly says,—"It is singular that the *Posidonia* should be the only shell at present known in strata of such extent and thickness as the Trias [in England], and the more so, as there seems no reason why the sea should not have been tenanted by other contemporary forms of Mollusks equally suitable to the same conditions of marine life:" the suggestion of Mr. Jones would remove this difficulty, by favouring the idea of a large lacustrine formation. In a paper by Mr. Plant, on the upper keuper of Leicester, the *Estheria* again performs a prominent part, being associated with plants and with fish-remains; and I may add, that Mr. Plant and Mr. Jones both recognize the discernment of Mr. Morris and of Sir C. Lyell, who had previously pointed out the crustacean character of the *Posidonomya*, though they had not fully established it by microscopical examination. I may observe that Geinitz places this form in the Permian strata, with a remark that it strongly resembles the thin shells of *Cypris*, and refers to the discussion by Delahaye and Landriot, who maintained its crustacean character in 1848.

Having thus given a sketch, as it were, of the labours of our Society, I must for a few moments turn to those of that national institution specially directed towards the development of Geological Science and the advancement of its most important practical application in this country: I mean the Museum of Practical Geology and the School of Mining Science associated with it. Without doubt there is no institution in this country of the formation of which the Government may well feel more proud, and there is none in which the duties allotted to it are carried on with more zeal and efficiency, though quietly and unostentatiously. Sir Roderick Murchison, its able Director-general, tells us that in England maps comprising an area of 2357 square miles have been published; that others, amounting to a further area of 996 square miles, are on the point of issue, and that an area of 774 square miles, comprising subdivisions of the oolitic, wealden, cretaceous and tertiary groups, complicated by faults, have been geologically surveyed preparatory to being mapped; that in Scotland the six-inch maps of Edinburgh and Haddington have received, or are receiving, the geological outlines of the coal-fields, and their associated deposits; that in Ireland 1604 square miles of country have been surveyed, and that sections have been run along 417 miles of wild and rugged coasts; so that we may fairly affirm that the officers employed, and especially the local directors, Professor Ramsay and Mr. Jukes, have done everything in their power to advance the progress of the work. But from the report of Sir R. Murchison there is one part of the establishment still kept much below the strength necessary for carrying on the work efficiently, and that is the Palæontological staff. Mr. Salter and his temporary assistants may be sufficient to keep pace with the collectors in England, and to ensure that fossils shall be examined, compared, and named soon after they have been found; but that he should be able to do the same for Ireland and Scotland is manifestly impossible, and in consequence, we learn that "although the Irish collections have been increasing at the rate of several thousand specimens per annum, no general examination of them has been made for the last eight years; nor, indeed any examination of them at all, except of a partial and necessarily imperfect nature, even when conducted by the late lamented Professor E. Forbes and Mr. Salter; the latter now alone executing the duties of Palæontologist of the United Kingdom." It is manifest that Sir R. Murchison asks only for what is absolutely indispensable when he urges the appointment of a Palæontologist for Ireland, and we may hope also one for Scotland. Of British fossils, 15,055 species have been classified, and of foreign, 545; 742 of these have been placed in the cases of the Museum; but, notwithstanding all the devotion of Mr. Salter and his temporary assistants, how is it possible, without further aid, that the fossils, which are the very elements of all Geological deduction, should be properly examined, and, still less, accurately drawn and rapidly published, so as to keep pace with the publication of the survey which depends upon them? I need not at present dwell upon the Museum of Jermyn Street further than to say that the Geological Survey itself is only one portion of the duties of the establishment connected with it. It forms, in fact, the head-quarters of a great educational institution including amongst its Professors some of the most eminent men of the country; each in his respective branch advancing the cause of sound practical education. Mr. Hunt has continued to preside over the Mining Record Office with great advantage to the statistical branch of Geology. Mr. Huxley, the distinguished naturalist, has during the session delivered a course of 50 lectures upon general natural history; Mr. Warington W. Smyth has, in addition to his labours in the field, whilst examining the mining districts, and to those of superintending the publication of his report on the Iron Ores of the North and North Midland Counties of England, and preparing the quarter sheets relating to the coal-fields of North Staffordshire for publication, delivered a course of 60 lectures on mining, and of 40 on mineralogy, besides an evening-course on mining for working-men. Lectures have been given to working-men by Professor Huxley on Natural History; by Professor Ramsay, on Geology; and by Professor Willis, on Applied Mechanics; the Chemical Laboratory has been ably managed by Professor Hofmann, and the number of his students has considerably increased; the Metallurgical Laboratory has in like manner been most ably managed by Dr. Percy, who, with his characteristic zeal for science, has not only applied his own mental resources towards the advancement of the instructional objects of the institution, and his skill in various analyses, but out of his own private funds has provided an assistant, and paid for many other expenses of the Laboratory. He has delivered a course of 50 lectures on metallurgy, and 6 evening-lectures on metals, to working men. Surely there is in this statement proof of a zeal and ability which cannot be overrated, cannot be overpaid; and it may well be expected that a people so remarkable as the English people are for sound common sense, will not fail to perceive, and to express their conviction founded upon that perception, that the Museum of Practical Geology is an institution for the people, and deserving therefore of their support.

Let me now close my address by a few observations necessarily occurring to my mind, as the result of these investigations. First, then, it appears to me, we are steadily progressing towards a knowledge of the material structure of the crust of the earth, and of the modifications it has undergone in the long course of ages; and such a knowledge seems essential to the right appreciation of many of the phænomena connected with the variations in the fauna and flora of the surface of the earth. In regard to the natural history of the earth, every day produces new genera and new species in every great section of geological formations; and yet this new evidence does not appear to approximate these sections together, or to bind them more into one great whole, so long as the test applied be identity of species, though unquestionably, if all the formations be taken together, every new discovery seems to supply a link, and to bring the organic elements of formations, widely apart as to time, into connexion as parts of one great and harmonious organic system. How then are we to account for this separation in time of the elements of a creation? Are we still, with Cuvier, to suppose that it has resulted from successive destructions of a partially constructed creation and successive renewals, each new creation supplying deficiencies in the preceding one, but producing others by leaving out some of the elements of the last; the creations, therefore, remaining imperfect? Or are we to suppose, with Blainville, that the work of creation was originally complete, and that the gaps now visible are due to the gradual dropping-out of certain of the links in the course of countless ages? Or are we to consider, with Lamarck and many others, that the present is only the development, through various successive stages, of the past, and that the limits of possible variation and transmutation of species, either by imperceptible steps of gradation or by periodic and sudden changes, regulated by the original law of creation, have not yet been determined? To one or other of these theories we must necessarily recur, and so far as the wisdom and power of the Great Creator are concerned, neither can augment or diminish it; for, admitting that creative power must have been exercised, it is indifferent whether it acted in the mode of Cuvier, or in that of Blainville, or in that of Lamarck. In every case the image of the whole must have been in the creative mind, and the wisdom equal, whether the creation was formed as a whole, and members of it were allowed to perish at certain intervals, corresponding to the successive physical conditions of the earth ; or, the whole creation being mentally determined by the Creator, those portions of it only which corresponded to the conditions of the earth's crust at each epoch were called successively into existence, various classes and genera attaining therefore the highest development under circumstances best suited to the requirements of their organization ; or, the final result having been conceived by creative intelligence, and certain members only of the great whole called into existence, like points on the circumference of a circle, and imbued with such a power of vital development, as should cause them in successive ages to fill up the whole space with an infinite variety of organic beings. The great discovery of Von Baer, of the existence of lower forms in the embryo-state of higher animals, has been supposed by speculative philosophers to favour the theory of development; but it does no more than prove that, whilst the animal is obliged to live under conditions different from those of his complete organization, no new form of organization is adopted, but simply one of those belonging to animals who ordinarily live under such conditions ; and, though the perfect animal has passed through such changes, the successive developments exhibited during the embryonic life of an animal, or during the period of a few weeks or months, or perhaps a year, can neither be taken as a proof of a separate individual existence, under either of the embryonic types, nor represent the changes which the same animal, as a species, may have really passed through in countless ages: on the contrary, it is more reasonable to suppose that this involved structure was adopted at the first creation of each species, and indicates only the simplicity and harmony of natural laws. If, however, the organic creation was effected as one great whole, and gradually diminished by the dropping-out of many of its links, either by generic or by specific death, how can we account for the total absence in the deposits of early times of any traces of the now living animals which were then co-existent with those of whom such abundant records have been preserved? To me it seems impossible to adopt such a theory without combining with it that of development. For not only must certain forms of organization have disappeared, but others must have so varied as no longer to be recognized as identical with those which have been revealed to us in the stony tablet of the earth.

I have already, more than once, alluded to the theory of colonies, proposed by M. Barrande, and I cannot deny myself the pleasure of once more recurring to it, and pointing out its great importance. Whilst then regretting, more than condemning, that ill-judged zeal, which, seeking to restrict the inquiries of man, by insisting that he shall take all his opinions of creation from that one book given unto man for a totally different object, I cannot but observe that the real history of the creation given in the Bible affords a wholesome caution to all those who endeavour to explain every act of the Creator as if He had been a man. Except as regards man, creation is not described as a work of manufacturing ingenuity, but as an act of infinite power: let the earth, let the sea, let the air bring forth things of their kind, was the fiat of the Almighty; and I cannot but think, that at each portion of the earth this fiat led to the production of genera and species suitable to the conditions of each, and to the appearance, therefore, in different localities, of species representative of, but rarely identical with, each other. On such a principle, how easy is it to understand that the colonies of M. Barrande should, although not identical with those species which had pre-existed in a locality, still have coexisted with them! Absolute identity would indeed be more opposed to the laws of creation than the slight variations we observe in closely allied species.

Let me too for a moment refer to that theory which would ascribe the destruction of species to the agency of man, and has sought to bestow upon the human race an antiquity far greater than that usually assigned to it. Doubtless the actual number of years of the existence of the human race might be multiplied ten- or a hundred-fold, and yet the problem left unsolved. Man, as a species, in a natural state, is restricted in his development by the hardships of life, and the difficulty of obtaining subsistence. So far from being an agent of destruction, beyond those limits which render the existence of the Carnivora compatible with the existence of the Ruminantia and other harmless animals, he, perhaps, of all animals, is the most feeble and defenceless, and it is only when he has become a civilized species that his race is capable of great development, and he becomes a really destroying agent. The ordinary history of the world is sufficient to prove this statement; and, if we compare the wide forest and prairie lands of America as they were 200 years ago, when the wild Indian tribes only killed for subsistence, and used for that purpose only the simple weapons which barbaric ingenuity had enabled them to form, with their present state, when civilized man has not only invaded their lands, but supplied the still uncivilized natives with the weapons of civilization, not merely to supply the wants of their own existence, but also to minister to the luxury of civilized man,—we shall see that the actual destruction of species, so far as the agency of man is concerned, could never have occurred, to any appreciable extent, had not that extraordinary phasis in man's existence—civilization—occurred; and I will add, that even civilized man would have required a vast extension of time to work out the destruction of species, had not the invention of gunpowder supplied him with an agent of almost unlimited power of destruction; and further, that, even provided with it, he has made but small progress indeed in the destruction of species. The Creation is, and must ever be, a mystery to man, and yet it is a speculation worthy of the exercise of the highest intelligence. Placed on the earth, it is our privilege to study everything connected with it, and we should be neglecting the highest endowments of our race were we not to do so; nor let us be tempted to scoff at or to condemn those who, possessed perhaps of a higher intelligence than our own, see further than we do, and adopt theories which appear to us absurd, sometimes only from our own inferiority; and above all, let us avoid that fatal error of connecting the results of scientific inquiry with the articles of religious belief. In attempting to discuss two widely different subjects at the same time, we must necessarily stumble. The speculation of a plurality of inhabited worlds, for example, is to the philosopher a proper mental exercise, though incapable of any positive solution; for, even supposing organic life to be compatible with every possible variation of physical conditions—a postulate at variance with the conditions of existence present on the earth, where life is limited on the one hand by the increase of pressure under the water, and on the other by its decrease in the air,—what more can we do than guess or speculate in the dark? Why then should we rashly connect such a speculation with the creed of the philosopher and the faith of the Christian, or assume the dream of the philosopher to be a proper measure of the Creator's wisdom? Let us then continue, as we have hitherto done, to pursue our investigations into the history of the earth, under all its various stages, unbiassed by any preconceived opinions, and unshackled by the dread of offending those who will not study the works of creation, but, remaining ignorant of them, consider that they are thereby the better fitted for discussing the Divine attributes. At all events, let us make truth, and truth alone, our aim, supporting our own appreciations of it when we have reason for so doing, but treating with calmness and forbearance the opinions of others who may differ from us: it is from such differences of opinion that we may expect ultimately to discover truth, sublimed from the dross of error which must ever be mingled with it in all those reasonings of man which cannot be actually based on mathematical principles, or reduced to positive demonstration.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 5, 1856.

George Brand, Esq., M.A., and R. Brough Smyth, C.E., were elected Fellows.

The following communication was read :—

On the Affinities of the Stereognathus ooliticus (Charlesworth), *a* Mammal *from the* Oolitic Slate *of* Stonesfield. By Professor Owen, F.R.S., F.G.S., &c.

[Plate I.]

The Rev. J. P. B. Dennis, F.G.S., lately did me the favour to place in my hands, for examination, the portion of jaw with teeth, imbedded in the oolitic slate of Stonesfield, Oxfordshire, which he had, two years before, submitted to Mr. Charlesworth of York, by whom the fossil was introduced to the notice of the Geological Section of the British Association at the meeting at Liverpool in 1854.

The portion of bone exposed to view is about 9 lines in extent, and is part of a ramus of the lower jaw, containing three molar teeth (Pl. I. figs. 1 & 2).

It is nearly straight; the side exposed is convex vertically, which indicates it to be the outer side; a slight bend downwards, and decrease of vertical diameter, towards the end a, indicate it to be part of a left ramus; the slight inclination of the cusps of the teeth (figs. 1, 3, & 4) towards the end A, might be deemed evidence of its belonging to the right ramus: but neither this degree of inclination, nor the position of the accessory cusp, fig. 3 *a*, are decisive of the way in which the fore end of the fragment points*. Not more of the matrix can be safely meddled with, on the small chance of more evidence to this comparatively unimportant point being had; and I shall, therefore, proceed with the description of the fossil on the assumption that the shallower end, A, is the front end, the deeper one, B, the hind end of the fragment, and that it is part of the left ramus of the mandible.

This ramus is unusually shallow, and broad or thick below, the side passing by a strong convex curve into the lower part; a very narrow longitudinal ridge, continued after its subsidence by a few fine lines, forms a tract which divides the lateral from the under surface: elsewhere the bone is smooth, without conspicuous vascular perforations. The depth or vertical diameter of the ramus is not more than two lines.

This portion of jaw contains three teeth, the middle one of which is the least mutilated; and by carefully removing the matrix which partly covered its crown, I exposed the whole of its singularly modified grinding surface. The first of the three teeth (figs. 1 & 2, *a*) appears to have been smaller than the others, but its crown has been too much broken to show its original characters. The third tooth, *c*, is less mutilated: it is of the same size and had the same structure as the middle one, *b*. Of this, the most perfectly preserved of the three, *b*, careful drawings have been made, magnified about 8 diameters, figs. 3, 4 & 5.

The crown of this tooth is of a quadrate form, 3 millimeters by $3\frac{1}{2}$ millimeters, of very little height, and supports six subequal cusps, in three pairs, each pair being more closely connected in the antero-posterior direction of the tooth than transversely.

The outer side of the crown (fig. 3), supported by a narrow fang which contracts as it sinks into the socket, shows two principal cusps or cones, *o*, *o'*, and a small (anterior) accessory basal cusp, *a*. A small portion of the outer side of the anterior cone, *o*, has been chipped off; that of the second cone, *o'*, shows a well-marked convexity. The hard and shining enamel which covers these parts of the crown contrasts with the lighter cement that coats the root, fig. 3, *r*. The two outer lobes or cones are subcompressed, and placed obliquely on the crown, so that the hinder one, *o'* (fig. 5), is a little overlapped externally by the front one, *o*, the fore part of the base of the hinder one being prolonged inwards on the inner side of the base of the front cone. The two middle cones (fig. 5, *h*, *i*) are subcompressed laterally, with the fore part of their base a little broader than the back part. The two inner cones, *p*, *p'*, have their inner surface (fig. 4) convex, with their summits slightly inclined forwards: a small portion of enamel has been chipped off the hinder lobe, *p'*.

* Compare the tooth, *m* 2, fig. 2 (*Hyopotamus*), Plate VIII., 'Quart. Journ. Geol. Soc.' vol. iv. 1848.

The fore part of the base of the hinder cone (fig. 5, p') is prolonged obliquely towards the centre of the crown, beyond the contiguous end of the base of the front cone, p, so as to cause an arrangement like that of the two outer cones, o, o': the obliquity of the posterior cone of both the outer and the inner pairs, o' and p', being such that they slightly converge as they extend forwards.

In the hindmost tooth, *c*, the two outer cones are broken off, showing that their common base is divided from the two middle cones by a deeper groove than that which separated the two outer cones from each other.

Thus the crown of these molars might be described as supporting three parallel antero-posterior ridges; the outer (fig. 5, o, o') and the inner, p, p', ridges being each divided by an oblique cleft converging forward toward the middle of the tooth; whilst the middle ridge, h, i, is divided by a curved cleft having its concavity turned forward.

The more mutilated state of the front tooth (fig. 2, *a*), of which only the base of the middle ridge of the crown remains, throws no additional light on the modifications of the very remarkable type of the grinding surface of the mandibular molars of the *Stereognathus*.

This type of tooth differs from that of all other known recent or extinct Mammals. The nearest approach to it is made by the true molars of some of the extinct Mammals from the most ancient of the tertiary strata, *e. g.* the *Hyracotherium* and *Hyopotamus*; but, in these genera, only in the molars of the upper jaw.

The two transverse ridges of the molars of the Manatee are each, when first formed, divided into three tubercles; but the clefts are so shallow that they are soon worn down, and a transverse strip of dentine bordered by enamel is exposed. In the *Stereognathus* the longitudinal clefts are deeper than the transverse one, and the result of abrasion would be to produce three antero-posterior strips of dentine, instead of two transverse ones. Nevertheless the temporary sex-cuspid character of the molars of the Manatee is interesting from being coupled with a short or low crown, and with a character of lower jaw, thick and rounded below, like that of the *Stereognathus*; but the ramus is proportionally deeper in the Manatee.

In the last upper molar of the Rat, before it is much worn, there are two transverse rows of three tubercles, but there is also a hinder lobe of two tubercles.

The ante-penultimate and penultimate lower molars of the Hedgehog (*Erinaceus*) show five or six cusps, but they are small, and only two occur on the same transverse line: the same remark applies to the multicuspid molars of the Shrews, the Galeopitheci, and a few other Insectivora.

In the upper true molars of the *Hyracotherium* * we have three pairs of cones, each pair being in the antero-posterior direction of the crown, and there being, consequently, two transverse rows of

* British Fossil Mammals, p. 419, cuts 165, 166; and Geol. Trans. 2 ser. vol. vi. pl. 21. figs. 1, 2.

three cusps, as in the *Stereognathus*; but the middle pair of cusps in the *Hyracotherium* are very small, appearing, in fact, as mere conical tubercular elevations of the middle of the ridge connecting the fore part of the base of the outer and inner principal cones.

In the *Hyopotamus* and *Anthracotherium**, the intermediate cone between the outer and inner principal cones of the anterior half of the molar tooth is developed to equality of size with them, and three cusps or cones are thus seen on the same transverse line of the crown. But there is no trace of the middle cone or tubercle (like that seen in fig. 5, *i*, between the outer, *o'*, and inner, *p'*, hinder cones), answering to the rudimental cusp in *Hyracotherium* and to the cone *i* in *Stereognathus*.

In the little *Microtherium* or *Cainotherium* of the miocene deposits of Germany and France the middle lobe or cone is developed between the pair at the back part of the upper molar, answering to cone *i* in fig. 5; but the cone answering to *h*, fig. 5, is not developed between the front pair of cones. This tendency, however, to lobes, cones, or cusps, in threes, in the older tertiary Mammals, is very significant evidence, as it seems to me, of the affinities of the small oolitic mammal having the above-described regular sex-cuspid molars.

The molars of the lower jaw of the *Hyopotamus* and other Anthracotherioids show no trace of a lobe or cone intermediate between the outer and inner cones of each transverse pair. The structure of the lower molars of the *Hyracotherium* is unknown: it is most probable, however, that the lower molars of the *Chœropotamus* would most resemble those of the Hyracothere; and in the penultimate and last grinders of the *Chœropotamus* a rudimental cusp appears between the outer and inner principal cusps.

The proportional size, and regularity of form, of the cones of the grinding teeth of the *Stereognathus* give a quite different character of the crown from that of the multicuspid molars of the Insectivora, and cause it to resemble more the quadricuspid or pentecuspid molars of the Artiodactyle non-ruminant extinct genera above cited.

I conclude, therefore, that, like the *Dichobunes*, *Xiphodon*, *Microtherium*, *Rhagatherium*, *Hyopotamus*, and *Hyracotherium*, the *Stereognathus ooliticus* was a diminutive form of the great Ungulate order of Mammalia, and that it most probably belonged to the artiodactyle or even-toed division of that order, and to the non-ruminant section of that division, the food of which, if we may judge from the existing hogs and peccaries, was of a mixed nature.

The interest which the above-described fossil from the Stonesfield oolitic slate excites is not exclusively due to its antiquity, its uniqueness, or its peculiarity: much arises out of its relations as a test, in the present state of Palæontology, of the actual value of a single tooth in the determination of the rest of the organization of an animal, or of so much of it as serves for a recognition of the place of the extinct species in the zoological series: the attempt, at least, to analyse the mental processes by which one aims at the restoration of

* Quart. Journ. Geol. Soc. vol. iv. pl. 7. figs. 1, 6, & 9.

an unknown Mammal from a fragment of jaw with a tooth cannot be wholly useless.

That the fragment in question is the jaw of a Mammal is inferred from the implantation of the tooth by two or more roots. Most Mammals are known to have certain teeth so implanted. Such complex mode of implantation in bone has not been observed in any other class of animals. The rule is deduced from the number of observations, positive and negative. Why two or more roots of a tooth should be peculiar to viviparous quadrupeds, giving suck, is not precisely known. That a tooth, whether it be designed for grinding hard or cutting soft substances, should do both the more effectually in the ratio of its firmer and more extended implantation, is intelligible. That a more perfect performance of a preliminary act of digestion should be a necessary correlation, or be in harmony, with a more complete conversion of the food into chyle and blood,—and that such more efficient type of the whole digestive machinery should be correlated, and necessarily so, with the hot blood, quick-beating heart and quick-breathing lungs, with the higher instincts, and more vigorous and varied acts, of a Mammal, as contrasted with a cold-blooded reptile or fish,—is also conceivable. To the extent to which such and the like reasoning may be true, or in the direction of the secret cause of the constant relations of many-rooted teeth discovered by observation,—to that extent will such relations ascend from the empirical to the rational category of laws. So much, briefly, at present, for the grounds of reference of the *Stereognathus* to the Mammalian class.

The broad sex-cuspid crowns of the molar teeth of the *Stereognathus* might crush vegetable matter or insect-cases: a recognition of their adaptability to uses observable in the nearest resembling teeth of existing animals leaves the above wide field of choice, or guess, as to the nature of the food of the oolitic animal. Let us take the latter hypothesis, and endeavour to work out more of the *Stereognathus* on the basis of its multicuspid and assumed insectivorous tooth. Insects fill the air, creep on the ground, burrow in the earth, move on and in the waters. In the living world of animals we have insectivorous molars associated with a frame and limbs modified for flying, running, burrowing, and diving. The principle of the mechanism for crushing insects being the same, it is secondarily modified in each genus of Insectivora; and so modified, though without affecting the crushing power of the tooth, that the odontologist discriminates at a glance the grinders of the Bat, the Hedgehog, the Shrew, or the Mole.

At present we can only refer such secondary modifications, as we do those of the more complex grinding teeth of the Herbivora, to that principle of *variety in non-essentials* which makes the leaf in each kind of tree unlike, and, as it is affirmed, which makes no two leaves, in any single tree, exactly alike.

If the tooth of the *Stereognathus* were like those of any known recent or fossil Insectivore, we should infer that the rest of its organization was like such Insectivore, and so classify it according to the degree of similitude. But as we know of no sufficient ground for the association of any given particular modification of the multicuspid tooth with such aërial, terrestrial, or aquatic modification, as the case might be, of the rest of the frame, our conclusion would be an empirical one ; and, having regard to the narrowness of its support from observation, would not be such as to leave the mind free from a sense of the possibility of its being liable to be proved to be an erroneous conclusion. On the hypothesis of the *Stereognathus* being an Insectivore, there is no known group or form of marsupial or placental Insectivora to which it can be referred.

The course of observation has shown that the teeth of the smaller kinds of hoofed Herbivora, such as the Peccari, the Hyrax, and the Chevrotains, approach in their cuspidate character, in the smaller amount of the cement, and in the simpler disposition of the enamel, to the form and structure of the teeth in the Insectivora. A nearer approach is made by some still smaller species of extinct hoofed quadrupeds, to which reference has been made in the body of this paper. The shape, disposition, and number of the cusps in the molars of the *Stereognathus* have appeared to me to be more like those in *Microtherium, Hyracotherium*, &c., than in any known recent or extinct Insectivore. Just in the ratio of this resemblance, therefore, is the inclination to view the *Stereognathus* as a hoofed rather than a clawed Mammal; as having been herbivorous rather than insectivorous, and as having been most probably a mixed feeder.

Physiology, or the known relations of organs to functions, helps me little in this determination: the small degree in which I feel the obligation is limited to the choice of the class: I acknowledge no aid from physiology in any degree of success with which I may have conjectured the nearer affinities of the *Stereognathus*. Can this example, we have then to ask, be justly cited as showing that there is no physiological, comprehensible, or rational law, as a guide in the determination of fossil remains; but that all such determinations rest upon the application of observed coincidences of structure, for which coincidences no reason can be rendered? I do not believe this to be the case.

I feel in the workings of my own mind what I believe to have operated in other minds, an irresistible tendency to penetrate to the sufficient cause of such coincidences—"to know the law within the law."

In the ratio of the knowledge of the reason of the coincidences of animal structures—in other words, as those coincidences become "correlations" to my conception—is my faith in the soundness of the conclusions deduced from the application of such rational law of correlations; and with the certainty of such application is associated a greater facility of its application. A knowledge of the rational law, or of the physiological conditions governing the relations, of the contents of the cavities of bones to the flight and other modes of locomotion in birds, both enabled me to infer from one fragment of a skeleton that it belonged to a terrestrial bird deprived of the power of flight, and to predict that such a bird, but of less rapid course than the Ostrich, would ultimately be found in New Zealand*. The support

* Transactions of the Zoological Society, vol. iii. p. 32. pl. 3.

of this conclusion being the higher law of the correlation of animal forms, as defined by Cuvier, gave me the requisite confidence in its accuracy.

Comparative Anatomy, as it was advanced by Cuvier, demonstrated to him this fruitful principle of the correlation of animal forms and structures. It was no *à priori* assumption : the founder of Palæontology expressly states—"l'anatomie comparée possédait un principe —celui de la corrélation des formes dans les êtres organisés, au moyen duquel chaque sorte d'être pourrait, à la rigueur, être reconnue par chaque fragment de chacune de ses parties *."

If the principle be true, then in proportion as the correlations are known will be the success and extent of its application. That there is such a principle of correlation the most assiduous and successful cultivators of Comparative Anatomy since Cuvier defined it have admitted. His successor in the chair of Comparative Anatomy at the Garden of Plants thus paraphrases his predecessor's definition: "Doubtless there reigns throughout all the solid pieces that enter into the composition of the skeleton of a vertebrate animal, but especially of a mammalian one, an appreciable harmony of number, form, position, proportions,—in a word, a combination which must have as its result such or such a kind or peculiarity of locomotion : so that one can pretty well prejudge or foresee, at least within certain bounds, by a physiological knowledge, certain osteographical peculiarities and *vice versâ* †." The consequence of the premises is here somewhat lamely expressed, but the admission of the physiological principle of correlation of forms is unambiguous. Something more than "certaines particularités ostéographiques" have been and will be foreseen through the above-defined law.

In certain instances of constant coincidences of structure, as demonstrated by Comparative Anatomy, the sufficient, *i. e.* recognizable, intelligible, or physiological, cause of them is not yet known. But, as Cuvier in reference to such instances truly remarks, "Since these relations are constant, there certainly must be a sufficient cause for them ‡."

In certain other cases Cuvier believed that he could assign that 'sufficient cause,' and he selects as such the correlated structures in a feline Carnivore, and in a hoofed Herbivore. The physiological knowledge displayed by him in his explanation of the condition of those correlations I receive as true. Its application in the restoration of the *Anoplotherium* and *Palæotherium* is exemplary.

* Discours sur les Révolutions de la Surface du Globe, 4to, 1826, p. 47.

† "Sans doute qu'entre toutes les pièces solides qui entrent dans la composition du squelette d'un animal vertébré en général, mais surtout de celui d'un Mammifère, il règne une harmonie appréciable de nombre, de forme, de position, de proportions, en un mot une combinaison qui doit avoir pour résultat tel ou tel genre de translation, telle ou telle particularité de locomotion ; en sorte que l'on peut assez bien préjuger ou prévoir, dans certains limites du moins, par une connaissance physiologique, certains particularités ostéographiques, et *vice versâ*."—*De Blainville, Ostéographie*, fasc. 1. p. 33.

‡ "Puisque ces rapports sont constants, il faut bien qu'ils aient une cause suffisante."—*Op. cit.* p. 50.

This principle, however,—those modes of thought—which Cuvier affirmed to have guided him in his interpretation of fossil remains, and which he believed to be a true clew in such researches, were repudiated or contested by two of his contemporaries.

Geoffroy St. Hilaire denied the existence of a design in the construction of any part of an organized body: he protested against the deduction of a purpose from the contemplation of such structures as the valves of the veins or the converging lens of the eye.

Beyond the coexistence of such a form of flood-gate with such a course of the fluid, or of such a course of light with such a converging medium, Geoffroy affirmed that thought, at least his mode of thinking, could not sanely, or ought not, to go. Now this objection has, at least, the merit of being intelligible: we know on what ground the adversary stands and what he would be at.

From this frank assertion of the tenets of the Democritic and Lucretian schools, those concerned in the right conception and successful modes of studying organized structures by the Young have little to fear. But the insinuation and masked advocacy of the doctrine subversive of a recognition of the Higher Mind,—the oft-recurring side-blows at Teleology,—call for constant watchfulness and prompt exposure.

It is not, however, my business here to go over the arguments which have been adduced by teleologists and anti-teleologists from Democritus and Plato down to Cabanis and Whewell.

In the degree in which the reasoning faculty is developed on this planet and is exercised by our species, it appears to be a more healthy and normal condition of such faculty,—certainly one which has been productive of most accession to truths, as exemplified in the mental workings of an Aristotle, a Galen, a Harvey, and a Cuvier,—to admit the instinctive, irresistible impression of a design or purpose in such structures as the valves of the vascular system and the dioptric mechanism of the eye.

In regard to the few intellects,—they have ever been a small and unfruitful minority,—who do not receive that impression and will not admit the validity or existence of final causes in physiology,—I am disposed to consider such intellects, not as the higher and more normal examples, but rather as manifesting some, perhaps congenital, defect of mind, allied or analogous to 'colour-blindness' through defect of the optic nerve, or the inaudibleness of notes above a certain pitch through defect of the acoustic nerve.

M. De Blainville chiefly based his opposition to the Cuvierian principle of correlated structures as applied to Palæontology upon the mistakes which Cuvier had made in their application, and on the limits within which he had been bounded when successfully applying them. For, admitting that the carnivority of an extinct animal could be deduced from an ungual phalanx, he asks, "What bone of the hand would assure you that the humerus of such carnivora was perforated, or otherwise, above the inner condyle? What bone of the fore-limb would tell you whether there was a clavicle or not, or an os penis*?"

* De Blainville, *op. cit.* p. 36.

I do not cite the other objections adduced in the Introductory Chapter of De Blainville's "Ostéographie;" because the author is compelled to take away the force of most of them by excepting the very bone on which the Palæontologist would found, correlatively, his conclusions as to the subordinate structure in question; as, for example, the os sacrum with reference to the determination whether the fossil animal had or had not a tail, and the os trapezium with reference to whether a fossil monkey had or had not a thumb*.

The inapplicability of the law of correlation, as contradistinguished from that of coexistence, to foreshow all the peculiarities of an extinct animal, is no argument against its applicability to a less amount of reconstruction.

After you have built up your Carnivore or Herbivore in a general way, agreeably with the correlations so truly and beautifully followed out, in either case, by Cuvier, he expressly teaches the necessity of careful and close observation of those secondary coincident structures by which you will be able to penetrate more deeply into the affinities,—in other words, to know more particulars of the structure—of the Carnivore or Herbivore under restoration.

The argument, therefore, against the Cuvierian rules of reconstruction is plainly devoid of force, which is based upon the inability to reconstruct, when the data, *e. g.* the *sacrum* for the tail and the *trapezium* for the thumb, are expressly excepted, whereby alone such reconstruction can be completed agreeably with the Cuvierian method.

Yet these relative shortcomings in the appliance of the principle, together with the mistakes which Cuvier sometimes made, on secondary points of affinity, in his surmises, before the requisite data for comparison were at hand, continue from time to time to be cast in the teeth of the disciples of Cuvier, as arguments against the principles by which they believe themselves guided and sustained in their endeavours to complete the glorious edifice of which their master laid the foundations.

I know no writer who more clearly defines, than Cuvier†, the limits within which the law of correlation of animal forms may be successfully and satisfactorily applied, by virtue of a knowledge of its physiological condition; or who indicates more candidly the numerous instances in which—the physiological condition being unknown, and the law, therefore, empirical, or one of coincidences,—careful and extended observation and rigorous comparison must supply the place of the more direct application of the physiologically-understood law. Through faith in Cuvier's interpretation of the physiological conditions of the correlations that flow from a hoof-bearing modification of the last joint of the toe of an animal, I accept his conclusions as to the herbivority of the extinct quadrupeds which he has called *Anoplotherium* and *Palæotherium*, and retain the conviction unshaken by any

* "De tous les os qui entrent dans le squelette du Magot, quel est celui, *sauf le sacrum*, d'où l'on puisse déduire qu'il n'a pas de queue?" p. 35. "Quel os, *si ce n'est le trapézoïde*, pourra vous conduire à assurer qu'un Sapajou de la division des Atèles n'a pas de pouce?"—*Ib.* p. 35.

† Discours, &c. pp. 49–53.

speculations as to the ease and possibility with which such hoofed quadrupeds might ride down and slay another animal. A domesticated recalcitrant animal may disable or kill his master by a blow of the hoof, but he does not therefore devour him.

The truth or fact of a physiological knowledge of the condition of a correlated structure and of the application of that knowledge to Palæontology is not affected or destroyed by instances adduced from that much more extensive series of coincident structures of which the physiological condition is not yet known. Nor is the power of the application of the physiologically interpreted correlation the less certain, because the merely empirically recognized coincidences have failed to restore, with the same certainty and to the same extent, an extinct form of animal.

Certain coincidences of form and structure in animal bodies are determined by observation.

By the exercise of a higher faculty the reason, or a reason, of these coincidences is discovered and they become correlations; in other words, it is known not only that they do exist, but how they are related to each other.

In the case of coincidences of the latter kind, or of "correlations" properly so called, the mind infers with greater certainty and confidence, in their application to a fossil, than in the case of coincidences which are held to be constant only because so many instances of them have been observed.

Because the application of the latter kind of coincidences is limited to the actual amount of observation at the period of such application, and because mistakes have been made through a miscalculation of the value of such amount, it has been argued that a rational law of the correlation of animal forms is inapplicable to the determination of a whole from a part*; and it has not only been asserted that the results of such determination are unsound, but that the philosopher who believed himself guided by such law deceived himself and misconceived his own mental processes! But the true state of the case, as I believe it to be apprehended by the working palæontologists since Cuvier's day, is, that the non-applicability of his law in certain cases is not due to its non-existence, but to the limited extent to which it is understood.

The consciousness of that limitation led the enunciator of the law to call the attention of palæontologists expressly to the extent to which it could then be applied, as, for instance, to the determination of the class, but not the order, or of the order, but not the family or genus, &c.; and to caution them also as to the extent of the cases in which, the coincidences being only known empirically, he consequently enjoins the necessity of further observation, and of caution in their induction. Cuvier expresses, however, his belief that such coincidences must have a sufficient cause, and that cause once discovered, they then become correlations and enter into the category of the higher law. Future comparative anatomists will have that great consummation in view, and its result, doubtlessly, will be the

* De Blainville, *op. cit.* p. 34.

Fig 3

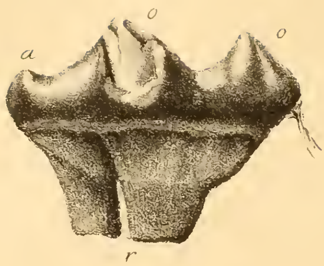


Fig 4.

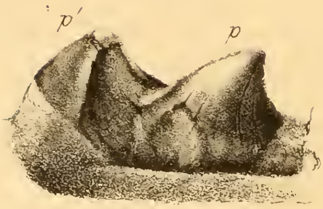
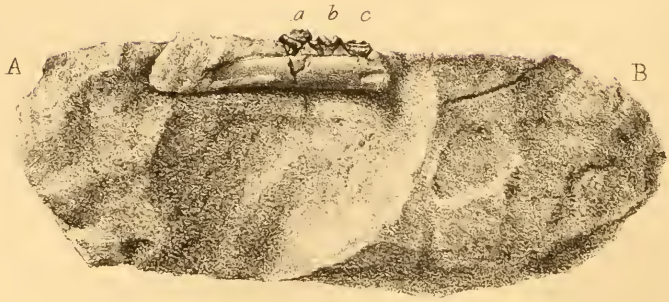


Fig 5

Fig 2.

Fig 1



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W West Imp

STEREOGNATHUS OOLITICUS. (Figs 1 & 2 nat. size)
from Stonesfield

vindication of the full amount of the value of the law in the interpretation of fossil remains, as defined by the illustrious founder of Palæontology.

EXPLANATION OF PLATE I.

Stereognathus ooliticus.

Fig. 1. Side view of the portion of lower jaw and three teeth, with the matrix: nat. size.
Fig. 2. Upper view of the same: nat. size.
Fig. 3. Outer side of the middle one (*b*) of the three teeth: magnified 8 diameters.
Fig. 4. Inner side of the same, similarly magnified.
Fig. 5. Upper or grinding surface of the same tooth, similarly magnified.

[The letters are explained in the text.]

NOVEMBER 19, 1856.

William Downing Biden, Esq., was elected a Fellow.

The following communications were read:—

1. *On the Occurrence of* CRYSTALLIZATION *in a* STUCCO-CASTING. By G. BUIST, LL.D., F.R.S., F.G.S.

IN 1847-48, having been much engaged in plaster-casting at Bombay, in the spring of the latter year I had thrown out a multitude of useless fragments, when, on the 28th and 29th of March, a furious thunder-storm and fall of rain occurred at the setting in of the monsoon. A week or so afterwards, as soon as the weather slightly cleared up, what was my astonishment to find nearly all the fragments presenting crystals of semitransparent selenite on their surfaces! These, on examination, were found partly imbedded in the earthy mass of stucco, in part protruding above its surface. When the specimens were taken indoors, the crystallization extended itself, and the whole mass became covered over with fine pearly spicula, like the crystals of the finest actinolite, only not radiating from points.

The stucco was prepared from a hard crystalline gypsum brought from the Persian Gulf; deprived of its water in the usual way, by being heated a little short of redness, then ground and sifted, and treated in the customary fashion. It was so absorbent that the rain disappeared from its surface almost as rapidly as it fell, so that the crystallization could not have arisen from saturation, in the ordinary sense of the term, or deposition from a menstruum.

I am not prepared to attach any influence to the thunder-storm: it was one of almost unprecedented violence and duration, and its occurrence seems worth mentioning, because on no future occasion was I ever able to obtain like results from exposure of stucco to the weather: there might at the same time have been peculiarities in the specimens thus transformed, of which I was unconscious.

The crystals are semitransparent, well formed, and deeply grooved axially along their faces. They are so perfectly unlike the material that surrounds them, that at first sight they might be supposed to consist of a different material altogether,—in place of being the earthy gypsum to which its water has been restored, and the molecular arrangement of which has been altered.

This unusual instance impresses strongly upon us the mystery attendant on dry crystallization. An old plastered wall is covered with long spicula of nitrate of lime, or actual nitre;—pieces of pyrites mixed with clay become decomposed, and long needles of sulphate of iron spring out of them. In the centre of the beautiful nests of laumonite are little groups of almost microscopic spicula springing from a common centre, radiating outwards, and to all appearance in the act of extending themselves. We have here not only a rearing in the molecules of the solid mass, but we have crystals built up, where there is no solution or menstruum around, of material not soluble in atmospheric air.

Along with these specimens of gypsum-crystals, I forward some specimens in which an alteration of another description in molecular arrangement is apparent.

The whole of India is surrounded by a border of marine deposit recently upheaved from the ocean; the organic remains contained in it being all recent. The arrangement of the beds is generally this: 1st (lowest). Old rock, fresh or decomposed on the outer surface; but the decomposed material, where such exists, undisturbed, as if its submergence had occurred suddenly but tranquilly, and it had never been worked upon or abraded by the action of breakers at all. 2nd. Blue clay—obviously detrital trap,—the same as forms the sludge or silt of our present estuaries and bays; this abounds with shells, and contains the roots of mangroves and other littoral bushes, to all appearance imbedded where they grew. 3rd. Above this clay is a mass of rough gravel, obviously rolled by the surge, and which must have been deposited under circumstances altogether different from those in which the light soft mud, now constituting the blue clay, was laid down,—turbulent and angry breakers having succeeded the pre-existing state of stagnation and repose.

The clay-beds are not unfrequently omitted,—the shell-gravel reposing at once upon the rock; and this gravel is for the most part cemented together into a solid mass, which forms a very serviceable building-stone, and is known by the name of "littoral concrete."

The larger shells, though perfect externally, and having the epidermis quite fresh, have lost the whole of the material of which they were originally composed, its structure having been entirely altered. The walls of the shell are changed into selenite, or into a fine, highly crystallized carbonate of lime,—and this transformation, although so entire, has in no way affected their general form, either externally or internally.

The blue clay also abounds with concretions of impure lime, which forms an excellent cement, and is known by the name of "kunkur,"—a term derived from a Sanscrit word meaning "nodule." The calcareous matter avails itself of any nucleus—such as a scrap of wood or piece of shell—which presents itself, and forms castings within, or moulds outside of these. In this way we have often delicate casts of crabs, lobsters, and molluscs, in which every atom of the original material has disappeared,—the internal structure has vanished, and a very perfect cast of the exterior remains.

The mangrove-roots prevailing in the blue clay are everywhere perforated by the holes of the *Pholas*, or some other borer. The perforations seem all at first to have been lined with a beautiful crust of calcareous sinter, varying from a few lines to a tenth of an inch in thickness. The structure of the whole, when broken across, is crystalline, arranged in ten, twenty, or thirty fine layers, slightly pinkish, and somewhat differing from each other in tint, and arranged like the striæ of satin-spar. This crust appears to have been produced by the percolation of water charged with lime.

Here once more a similar transformation to that previously described appears. A little of the surrounding clay seems at first to intrude itself, and, gaining volume and consistency, first fills up the crystallized tubes in front, and, the limestone gradually disappearing, finally remains in its place as a perfect cast of the original boring. All degrees of the transformation are found in abundance.

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2. *On the Occurrence of* Allophane *at* Charlton, Kent.

By J. Morris, F.G.S.

For some time past a substance, having at first sight the appearance of amorphous carbonate of lime, has been noticed as occurring at the chalk-pit near Charlton, and to which the workmen applied the term "petrified water." It was found in more abundance than at present during the progress of the old workings through some parts of the pit, although it is still to be obtained.

This substance, which has been carefully analysed by Mr. Dick, of the Metallurgical Laboratory of the School of Mines, Jermyn Street, proves to be allophane, which has not, I believe, hitherto been recorded as a British mineral. A brief notice of its mode of occurrence may therefore be useful to those who are interested in the formation of minerals, and may possibly stimulate some farther inquiry as to its origin.

Allophane and the allied species are hydrous silicates of alumina, which differ in the relative quantities of silica, alumina, and water they contain, the latter ranging above 40 per cent. in scarbroite and allophane.

The nature and position of these minerals would seem to indicate that their origin is due to the slow action of chemical and other agencies upon the rocks with which they are associated, or more generally, as in the present case at Charlton, on the strata superposed to the rock in the fissures of which latter the mineral is deposited.

The Charlton pit exposes from 15 to 20 feet of chalk-with-flints, which is traversed, independently of joints, by numerous fissures, ranging nearly in a north and south direction (N.N.E. by S.S.W.);

the principal fissures coinciding with lines of small faults averaging about 2 feet in their displacement: in fact, the chalk appears to have been subjected to much lateral pressure; for, independently of the appearance of the chalk itself, which is occasionally shattered, the flints near to or in the fissures are fractured, and the sides of the fissures present in some places a striated appearance, as if they had been rubbed against each other in a vertical direction, and coincident with the displacement of the rock. The fissures vary in size, and their upper parts frequently present an irregular funnel-shaped structure.

The movements above alluded to were probably due to that general disturbance which has affected the whole area, and has been partly described by the Rev. H. M. De la Condamine, in his paper "On the Tertiary Strata and their dislocations in the neighbourhood of Blackheath*."

The derangements of the chalk must have taken place posteriorly to the deposition of the superior tertiary strata; for, although the upper surface of the chalk presents an undulating appearance, and the layer of green-coated flints lying above may be said to repose on a tolerably even surface, yet indications of slight disturbance may be observed in this stratum, parallel to the lines of faults, and which could not, of course, be readily observed in the sand above.

With this band of flints, generally encrusted with silicate of iron, are associated thin seams of clay, clayey sand, and impure fuller's earth; and these are overlaid by the well-known "ash-coloured sand" (Thanet Sand) so characteristic of this portion of the series.

No trace of allophane has been observed in the ash-coloured sand, nor does it form a continuous layer on the surface of the chalk.

The greatest quantity is met with near to, and in, the funnel-shaped cavities, and also lining some of the fissures previously mentioned.

It occurs in different ways; sometimes forming layers following the irregularities of the cavities; sometimes intermixed with the ochreous sand and clay, and coating the flints (which have been previously abraded) with a more or less thickened crust; at other times it may be observed formed into large concretions, which, upon drying, present a concentric arrangement. The allophane is continued downwards, lining the fissures (which are irregular in width) on each side, in the manner of the gangue of a vein, and even filling them up, and encrusting any fragment of chalk-flint or broken flints that existed in the fissure. The allophane is found in the fissures to the present depth of the workings in the chalk (about 15 to 20 feet), and is probably continued further downwards.

One of the principal veins containing the allophane occurred in the middle of the pit, and is now worked out, traces of it remaining on the north and south sides; the chalk on each side was rotten, presenting lines of irregular vertical cleavage, probably owing to the lateral pressure it had undergone. On the south side the fissured chalk, about 8 feet wide, was traversed by small veins of allophane,

* Quart. Journ. Geol. Soc. vol. vi. p. 441; *ibid.* vol. viii. p. 193.

which, meeting below, again separated, and surrounded a large mass of broken chalk; the allophane penetrated the adjacent chalk, which for a short distance on each side was marked by numerous fine ferruginous lines arranged parallel to the fissure.

At the west end of the present workings other fissures are visible (Nov. 1856), which I have occasionally examined during the progress of the works. They extend in the same direction, N.N.E. by S.S.W., dipping about 80° east; the sides are much striated, and the adjacent chalk is spotted with ferruginous stains. The allophane varies in thickness and texture, being sometimes resinous, or occasionally earthy; and the flints, which are here sometimes very much crushed, are re-cemented by it. In the vein were patches of a dark powder, consisting of oxide of iron mixed with a little manganese. The allophane following the upper part of the line of fissure is more earthy, about 4 inches in thickness, and is separated from the greenish sands and flints by a thin layer of ochreous clay and impure fuller's earth.

The allophane is amorphous, investing, and mammillated, translucent or semitransparent, with a somewhat vitreous lustre, but sometimes dull and opake, especially when pure white.

The colour varies much, either pale lemon or amber, and occasionally deep reddish-brown. Its specific gravity is about 2. Fracture of translucent masses is brittle; the dull earthy varieties are conchoidal in fracture, and adhere strongly to the tongue.

The following analysis is by Mr. Dick:—

Silica, 18·89; alumina, 33·52; water, 42·73; lime, 1·67; carbonic acid, 2·51; and a trace of organic matter.

In viewing the circumstances under which this substance occurs, it is evident that it must have been deposited from a fluid or viscid state, not only after the denudation of the chalk and the deposit of the partially abraded flints which are coated with it, and after the accumulation of the ash-coloured or Thanet sand, but subsequently to the disturbance of the whole series, whereby the fissures in the chalk were formed, and in which the allophane is now found. From its chemical composition it is inferred that the formation of the allophane originated in the overlying tertiary strata; but in what manner is an interesting subject for chemical inquiry, for we cannot always estimate the effects of the long-continued action of chemical and electrical agencies, modified perhaps by temperature, in the ordinary processes of nature. Silicate of alumina is but sparingly soluble; still the percolation of water, either pure or carbonated, acting upon the previously decomposing clay or clayey sand*, or decomposing them and disarranging the equilibrium of the original substance, may have caused the original or remaining elements to be re-adjusted†,

* The ash-coloured or Thanet sand consists of argillaceous sand, mixed with numerous grains of a dark green substance, which may have been derived from the previous destruction of some igneous rock containing augite or some other silicate of iron.

† "Some one element or more," remarks Dana, "by the influence of external agents, enters into new combinations and is removed; this disorganizes the

and new attractions to arise in their then nascent state, by which those elements constituting the allophane may have united and passed off in solution, and, flowing downward, been deposited among the flints and in the fissures of the chalk below*.

Under somewhat similar circumstances to those of its occurrence at Charlton, allophane is met with in the chalk near Beauvais in France, where the lower tertiary sands are superposed on that rock.

The slight variation in the chemical formula of some of the hydrosilicates of alumina would lead us to infer that several mere varieties in this group have been described as distinct mineral species, the differences of which might be more clearly understood by a careful investigation of the conditions under which these minerals occur in nature, rather than the mere study of them in the cabinet.

Scarbroite† or kollyrite, another hydrosilicate of alumina, is found in fissures of a grey or ferruginous impure shelly limestone, belonging to the lower oolitic series of Yorkshire, which is covered by the thick series of sandstones and shales containing plants; it also occurs in the ironstone and sandstone with plants of the same coast. It is allied to pholerite‡, a mineral which Mr. Prestwich has detected in the ironstone-nodules of the coal-measures at Coalbrook Dale.

During the important investigations (under the direction of Dr. Percy, at the School of Mines) in the chemical composition of the different iron-ores of Britain, a white powder (probably pholerite) was observed, associated with some of the clay-ironstone; the following is its analysis by Mr. Dick:—

Silica, 41·78; alumina, 36·99; water, 14·26; peroxide of iron, 4·51; lime, ·48; magnesia, ·16; alkalies undetermined.

I have also collected a similar mineral substance occurring on the surface and filling the crevices of the white oolite of Lincolnshire, where this rock is covered by the soft shales, sandstones, and clays belonging to this series. It has probably originated in the same manner as scarbroite and allophane, by the decomposition of some of the mineral substances of the overlying strata.

original compound, and leaves the remaining elements free to combine anew; such as are capable, consequently unite by their affinities, either alone or with water, or other chemical agents present; the excess, if any, and soluble, passes off in solution."

* "Hydrated peroxide of iron decomposes silicate of alumina in such a manner that there is a partition of the silica between the bases, and a double silicate formed. It cannot be supposed that water ever contains hydrated peroxide of iron, but carbonate of iron is almost constantly present. When, therefore, water comes in contact with a mineral containing silicate of alumina, all the conditions for decomposition, whether partial or entire, are present: the protoxide of iron passes by oxidation into peroxide, and this reacts with the silicate of alumina; while the carbonic acid, liberated at the same time, decomposes other silicates in the mineral."—G. Bischof, Elements of Chemical and Physical Geology, vol. ii. p. 77. Translation by B. H. Paul, F.C.S. (Cavendish Society).

† See Dr. Murray's notice of this mineral, Twenty-third Report of the Scarborough Phil. and Archæol. Society, 1855, p. 27.

‡ "Of frequent occurrence in crevices of the ironstone-nodules, especially the Pennystone, in the casts of plants in ironstone," &c.—Geol. Trans. 2 ser. vol. v. p. 487.

The following Table exhibits a comparative view of the composition of the allied mineral substances alluded to above :—

		Silica.	Alumina.	Water.		
Allophane	Beauvais	21·90	29·20	44·20	Clay 4·7	Berthier.
———	Charlton	18·89	33·52	42·73	Carb. lime 4·38	Dick.
Kollyrite	Ezquerra	15·	44·5	40·5	....	Berthier.
Scarbroite	Scarborough ..	10·50	42·50	46·75	Ox. iron ·25	Vernon.
Pholerite ..	Fins	41·65	43·35	15·	....	Guillemin.
——— ...	?	41·78	36·99	14·26	Peroxide of iron 4·51, magnesia ·16, lime ·48	Dick.
Halloysite	Anglar	44·94	39·06	16·00	....	Berthier.

3. *On the* Red Sandstone *and* Conglomerate, *and the* Superposed Quartz-rocks, Limestones, *and* Gneiss *of the* North-west Coast *of* Scotland. By James Nicol, F.R.S.E., F.G.S., Professor of Natural History, Marischal College and University, Aberdeen.

Contents.

Introduction.—The Red Sandstone and Quartzite rocks on the north-west coasts of Sutherland and Ross possess many features of interest, which have long attracted the attention of geologists. The mountains, rising abruptly from the great table-land of lower hills in smooth rounded cones, spiry peaks, or long serrated ridges, their hoary summits shining in the sun like new-fallen snow, and sending down streams of rugged fragments to the deep sea-lochs that, running far up into the interior, wash their bases, present scenes of wild and varied grandeur unknown in other parts of the island. Nor does a closer examination lessen the wonder with which we regard these mountains. They are then found to consist, not of granite or igneous rocks, nor of the older so-called primary strata, crushed up and broken by some great convulsion, as their singular outlines might have led us to expect, but of stratified rocks of no great hardness, lying almost horizontally in thin even beds, and moulded into these strange forms by the slow agency of natural causes. Many authors have consequently been induced to notice them, from the time when Pennant, deceived by their external aspect, described them as formed of white marble; and Williams, with a more accurate knowledge of mineralogy, as granular quartz*. Of these it is sufficient to mention the memoirs 'On Quartz Rocks,' and the volumes on the Western Isles by Dr. Macculloch†, the very valuable memoir on the Conglomerates and other Secondary Deposits on the North Coasts of Scotland by Professor Sedgwick and Sir Roderick I. Murchison‡, and the 'Geognostical Account of Sutherland' by the late Mr. R. H. Cunningham§. These well-known works might be supposed to have exhausted the whole subject; but the discovery, in the winter of 1854–55, of better-preserved and more distinct fossils by Mr. Chas. Peach in the limestones of Durness invested these rocks with a new interest. Sir R. I. Murchison, wishing to verify his former observations, revisited this region in the autumn of 1855, and, having kindly requested me to accompany him, we examined several of the most important sections together‖. Last summer I returned to the west coast, and visited several points which we had passed over in the previous year. As my observations now extend over almost the whole tract, from Cape Wrath and Durness on the north to Loch Alsh and Skye on the south, I am induced to lay the results before the Society, in the hope that they may throw some light on these interesting formations¶.

Sections in the Northern part of the District.—In describing the rocks I shall commence with the sections seen near Ullapool, on Loch Broom, as these are apparently typical of the relations in other localities, which they thus tend to explain. Measured from the outer headlands, this bay, or sea-loch, runs for more than twenty miles into the interior, intersecting successively all the various formations. Both shores are formed by ranges of hills, descending abruptly to the water, and generally very thinly covered either with

* Pennant's 'Tour in Scotland'; Williams's 'Natural History of the Mineral Kingdom.'

† Memoirs 'On the Geology of Various Parts of Scotland,' and 'On Quartz Rock,' in Geological Trans. 1st series, vol. ii. pp. 388 and 450; Western Isles of Scotland, vol. ii. pp. 89, 508, 675.

‡ 'On the Structure and Relations of the Deposits contained between the Primary Rocks and the Oolitic Series in the North of Scotland.' Geol. Trans. 2nd series, vol. iii. p. 125.

§ In the Transactions of the Highland Society, vol. xiii. p. 73–114.

‖ See Report of British Association (Glasgow) for 1855; Trans. Sect. p. 85.

¶ In justice to my predecessors I may mention, that at the time they examined the West Highlands there were even less facilities for visiting these remote parts of the country than at the present day, when steamboats have done so much to render them accessible. The uncertain climate, too, places a great bar to geological investigations; and Sedgwick and Murchison specially state, that the stormy and wet weather which they encountered in these districts prevented their full exploration of the mountains. Sir R. Murchison and myself, in 1855, were again impeded in our researches by the rains and mist that so frequently obscure the best and most instructive sections on this humid coast.

detritus or vegetation. The outcrop of the beds is thus very clearly exhibited, and the relation of the formations easily ascertained, not only in the cliffs on the shore, but to the very summit of the mountains. The village of Ullapool is situated on a flat promontory formed by the detritus thrown into the loch by the Auchal river; and, as it lies not far from the junction of the various formations, forms the most convenient point for investigating them. The section (fig. 1) represents the general relations of the rocks on the north side of the loch. It commences on the N.W. with an imperfect outline of the Coygach Hills, intended merely to show some of the peculiar features which the red sandstone mountains assume on this coast. Some of them rise into fine spiry or serrated summits, whilst Ben More, the highest, forms a long narrow and precipitous ridge, running to the north-east.

The part of the section specially examined begins at Loch Kennort. On its north-west shore, at the foot of Ben More, a thick mass of red sandstone, divided into numerous beds, dips to the south-east at a low angle (10° to 12°). This rock, with approximately the same dip, appears also to form Martin Island, lying in the mouth of the bay. On the south-east shore the red sandstone again crops out in thick craggy masses, with a dip of 12° to 20° to the south or south-west, the beds being apparently broken and curved. In the ridge to the east the rock is well exposed, dipping 10° to 12° to S. 20° E.* This dip continues nearly constant, both in amount and direction, throughout the next range as far as the Auchal river, occasionally perhaps inclining a little more to the east. In some places, even where the rocks are well seen, the dip is obscured by the powerful glacier action which has smoothed, striated, and rounded the rocks of the entire region†. Throughout the whole of this range, the red sandstone is very uniform in aspect and mineral character. Most of it is a rather coarse grit, graduating into a fine conglomerate, with fragments rarely an inch or more in diameter. The fragments are not much water-worn, and consist especially of quartz, hornstone, and felspar,—the last often decomposed. The grits are composed chiefly of rounded grains of grey vitreous quartz and red felspar (orthoclase), but apparently with no mica‡. The general colour is dark brownish red; but some portions are of a lighter red, or yellowish tinge.

The Auchal river near Ullapool has cut a deep gorge in the sand-

* From the large variation of the compass (30° or more), I have thought it better to correct the directions throughout this paper.

† The violent pressure of the ice appears also to have occasionally altered the position of large masses of rock, thus vitiating direct observations made on the strata at their outcrop.

‡ Dr. Macculloch has already made the observation as to the West Coast sandstone generally—"In no instance have I observed it to contain mica, nor, with the exception of red jasper and that of the schist just mentioned, any substance but quartz and felspar." On the other hand, Sir R. Murchison (Trans. Geol. Soc. 2nd ser. vol. iii. p. 164) mentions the occurrence of mica in some beds of the red sandstone of Applecross, so that it is rather rare than unknown. Macculloch also says, "that in no instance hitherto has it been found to contain imbedded limestone."—Western Isles, vol. ii. p. 97.

stone, which forms the base of the next hill, and is well exposed, both on the road and on the shore east of the town. It is seen to be covered by the quartzite; but the continuation of the section is obscured by detritus, which has collected behind a rocky promontory projecting into the loch. This promontory consists of a massive intrusive rock, in some places a kind of syenite, or a felspar-porphyry with hornblende, in others rather an impure serpentine*. In one place it is covered by a bed of quartzite; but on the shore to the east the first strata seen are thin-bedded grey gneiss, dipping 17° S. 5° E., but the beds are often much twisted and contorted. On this line, therefore, the relations of the quartzite to the gneiss are not very clearly exhibited; but that it overlies the red sandstone is beyond doubt.

The valley of the Auchal river lays open a still more instructive section. The north-west side of the valley is the continuation of the same range which forms the coast; and, as shown in the section (from A to B), the red sandstone distinctly dips under the white quartzite forming the summit of the hill. The continuation of the same beds, with the same relations, is seen on the other side of the valley, followed by the road from Ullapool to the north-east. The lower and larger portion of the quartzite, that overlies the red sandstone, is of a pure white colour on the exterior, and often with a polish like glass, from the ice-action to which it has been exposed. In the interior the rock has often a reddish tinge, from a mixture of felspar. The principal constituent is however quartz, in very fine grains, rarely as large as mustard seeds. Mica seems wholly wanting, or very rare. Some of the beds of quartzite contain cylindrical bodies, simple or branched, and from a quarter to about half an inch in diameter, running vertical to the strata; whilst others contain similar bodies, but of a conical form,—both of them often in such numbers as to cover the entire surface. Higher in the series a fine-grained grey siliceous rock occurs, containing so much iron in layers or nodules, as to become brown and rotten when exposed to the weather. The surfaces of the thin layers of this rock are often marked by plant-like impressions, resembling a confused mass of fucoids. I now notice these markings chiefly from their importance in identifying the beds, reserving their supposed organic origin to a subsequent part of this paper. The quartzite is usually distinctly stratified, in beds of one to two or three feet in thickness. It is also divided vertically by "backs and cutters," like those in the sandstones of the coal-formation. One bed is also divided into small oblong masses, like beds of clay-ironstone, but appeared to consist chiefly of quartz.

The quartzite is followed in the ascending section by a thick mass of limestone, quarried in several places and cut through by the river in a picturesque gorge. Even where not exposed, its presence may easily be recognized by the bright green pasture that covers it. The

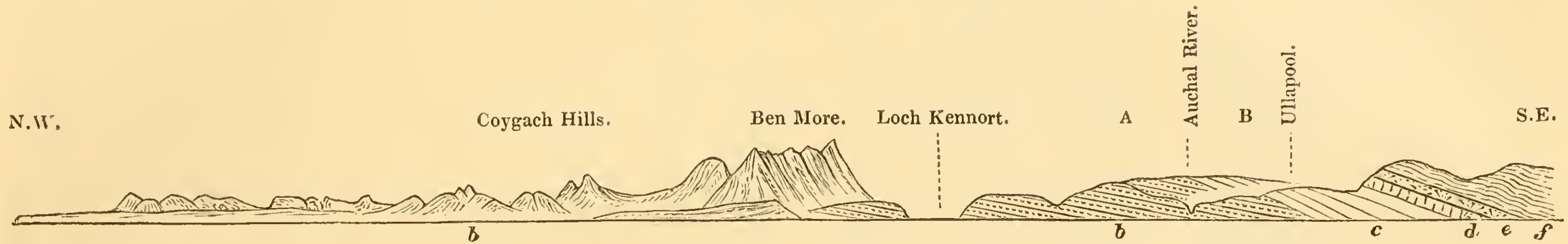
* From its variable character it is difficult to give this rock a name. Probably it is a felspar-porphyry or binary granite, becoming a serpentine where in contact with the limestone of the quartzite.

limestone is of a bluish-white or grey colour, and intersected by so many minute veins as to give it a brecciated structure. It is very much hardened, and often siliceous. Interstratified with it are thin beds of finely laminar shale; the laminæ are often as thin as paper, and some of them light grey, others black and carbonaceous. The general dip of the quartzite and limestone series of beds is about 15°–20° to S. 60° E., thus at a higher angle and in a more easterly direction than the red sandstone on which they rest. In the valley of the river the limestone is followed by the same serpentine, or felspar-porphyry rock, observed on Loch Broom, and this along Loch Auchal by gneiss, dipping to the south-east. The immediate relations of the rocks are, however, concealed by the lowness of the ground and the thick cover of moss and grass.

Any doubt on this point is removed by examining the hill between Loch Auchal and Loch Broom, in the line followed by the section. The quartzite just described forms the first low acclivity, resting on the red sandstone. Beyond a slight depression, the ground rises more rapidly; and, on the steep slope, first the limestone crops out, then the serpentine, and above all the gneiss, forming the summit of the hill, where it dips at 10°–15° S. 30° E., though with slight undulations. The rocks may be traced round the south side of the hill, placing their relations to each other beyond all doubt. A vertical section through the summit would pass in succession through the gneiss, serpentine, limestone, quartzite, and probably the red sandstone.

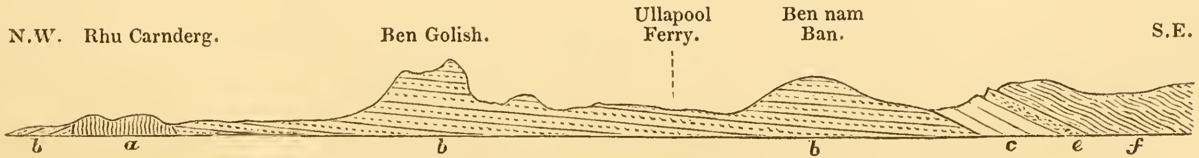
The section (fig. 2) on the south of Loch Broom is, if possible, still more explicit. The western portion was only seen in sailing along shore, as there is no road on this side of the loch, and the cliffs are in many places inaccessible; but the eastern, and most important part, was examined on the ground. At the north-west extremity the red sandstone dips out to the sea, but is soon interrupted by rocks represented as gneiss by Macculloch, and probably the continuation of those subsequently noticed near Loch Greinord. The red sandstone again commences dipping steadily to the south-east, along the whole loch, to beyond Ullapool. From the Ferry, its general dip is about 8° to S., 60° E., or S. 75° E., in thick, regular beds. According to Macculloch's map, the red sandstone is immediately followed by gneiss; but, as the section shows, this is not the case. Before reaching Logie, it gives place to the quartzite, dipping at 15°–20° to S., 70° E. Besides the common quartzite, I found both the beds with cylindrical bodies, and those with fucoid impressions observed on the north shore. I could not, however, discover the limestone, the quartzite being immediately succeeded by a thick mass of the serpentine or porphyry, running as a bold overhanging cliff, obliquely up the side of the hill, nearly in the dip of the beds. I traced it from the shore to the top of the ridge, and it apparently extends round into the valley at the head of Little Loch Broom, forming the cliffs beyond Dundonald. From its great hardness, it projects in a broad ledge or terrace, but is covered by gneiss, dipping at 23° nearly due east; and, like that on the north shore,

Fig. 1.—*Section along the North side of Loch Broom.*



f. Gneiss (upper).
e. Serpentine or felspar-porphyry.
d. Limestone.
c. Quartzite.
b. Red Sandstone.
a. (Wanting.)

Fig. 2.—*Section along the South side of Loch Broom.*



f. Gneiss (upper).
e. Serpentine or felspar-porphyry.
d. Limestone.
c. Quartzite.
b. Red Sandstone.
a. Gneiss (lower).

Fig. 3.—*Section along Loch Assynt.*

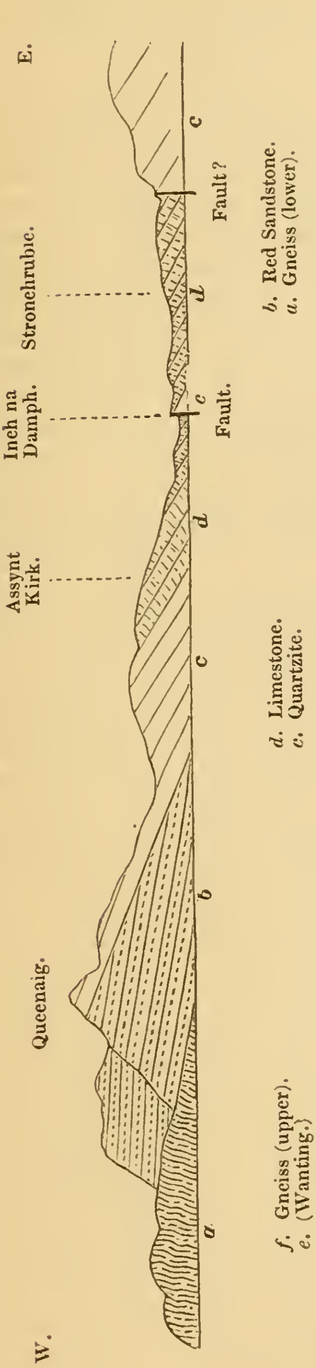
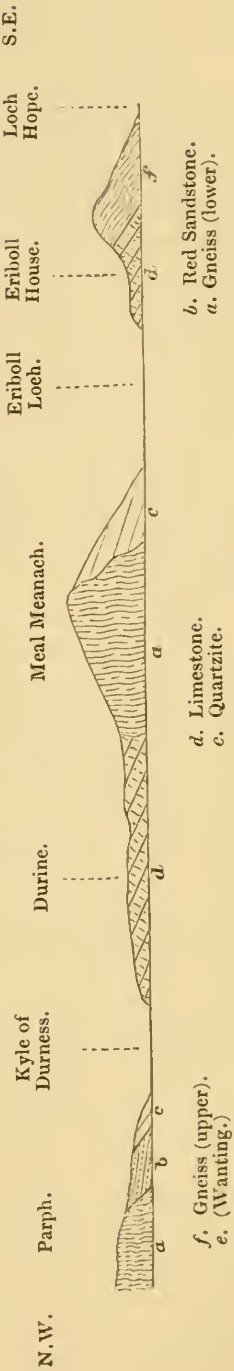


Fig. 4.—*Section from Durness to Eriboll.*



forming thin beds, often curved and twisted. Near the igneous rock the gneiss is in general very fine-grained, almost compact, and composed chiefly of quartz, with a little felspar and minute scales of mica. Many portions seemed almost like the more argillaceous beds in the quartzite series,—in a highly metamorphic state.

In this section there is thus the same, or rather a more complete, succession of the formations in the same relative order. The red sandstone, resting on gneiss, is covered in ascending order by quartzite, serpentine, and gneiss. The north side of Little Loch Broom exhibits these relations even more clearly, as the hills are more precipitous, and the superposition of the quartzite on the sandstone more fully exposed. I had not an opportunity of examining the junction of the quartzite and gneiss in the valley beyond this loch; but in the fine ridge of Kea Cloch, on its south side, the white quartzite is clearly seen running up over the red sandstone that forms the lower declivities. The red sandstone, dipping at a low angle to the south-east, continues along the coast for several miles, but is at length interrupted by a mass of serpentine or serpentinous gneiss, like that seen rising from below the sandstone mountains near Loch Greinord. Beyond this rock the sandstone, in thin slaty beds of a bluish-white colour, dips at 10° to N., 20° W., forming the outer headland.

These sections in the centre of the formations may be regarded as typical of the phænomena in other localities; but several, both to the north and south, present some peculiarities worthy of notice. One of the most interesting of these is in the vicinity of Loch Assynt, where the precipitous sides of Queenaig, and the other mountains that surround that beautiful lake, expose some remarkable sections. I examined these in 1855 with Sir R. Murchison, and had thus the benefit of his former knowledge and experience in determining their relations. Though less clear than at Ullapool, probably from having undergone greater disturbance, the relative position of the formations appears to be essentially the same; see fig. 3. On the west, towards Loch Inver, the country consists of rounded, gnarled knobs and bosses of gneiss, separated from each other by small lakes and dark moors, and heaped together without any very apparent order. Near Loch Inver the gneiss often contains hornblende in place of mica; and some varieties are a granular compound of felspar and hornblende, containing large imbedded masses of light green fibrous hornblende, some of them two feet in diameter. These hornblendic varieties of gneiss are very characteristic of this formation in the west of Sutherland, as far north as Cape Wrath. On Loch Assynt the gneiss has often its common aspect; but coarse laminar hornblendic varieties, with no mica, and large nodules of quartz, still prevail. About half-way up the lake, the gneiss, dipping at 55° to the west, is covered by red sandstone, dipping at 5° or 10° to E.N.E. The lower beds of the sandstone are a conglomerate of quartz, felspar, and gneiss; the largest fragments are about two or three inches in diameter, and not much rounded. Higher up it is a dark, brownish-red, laminated rock, often containing large pebbles of quartz, and a few traces of blue carbonate of copper. The sandstone is covered by the quartzite, the first beds being a coarse grit, with fragments as large as peas; and those higher up, a fine-grained white stone with a vitreous lustre. At Skiag Bridge, where the road turns north to Kyle Scow, the quartzite is of a red colour, and contains numerous cylindrical bodies, like those noticed near Ullapool. Ascending the hill by this road, we found brown slaty beds, with fucoid or plant-like impressions; and higher up again a bed with cylindrical bodies, thus identifying the strata with the Loch Broom rocks. On the line of section along the lake, the quartzite is succeeded by limestone, generally of a white or blue colour, and with a fragmentary or brecciated structure. Near Stronchrubie, east of the inn at Inch na Damph, the same limestone is well seen, ranging along the fine precipitous cliff. In this place it is often cherty, containing masses of siliceous matter like those common in the mountain-limestone, and also druses lined with quartz-crystals. Large lumps or masses of red felspar also occur in it; and a bed of greenstone, of augite and dark-red felspar, runs along the face of the cliff. The quartzite with cylindrical bodies again crops out at the bottom of the escarpment below the limestone, so that the whole series has probably been brought up by a fault. In the hills behind, according to Mr. Cunningham, the limestone is again covered by quartz-rock, as drawn in the section; but this locality I did not visit*.

This section is evidently identical with that on Loch Broom, both in the mineral character and relative position of the beds. The only difference is in the apparently greater thickness of the limestone, and in this being again overlaid by quartzite. As on Loch Broom, also, the quartzite is unconformable to the red sandstone, and dips at a higher angle than the rock on which it rests. This is well seen on the south side of Queenaig, where the white quartzite creeps up, as it were, gradually over the red sandstone beds. The flank of the mountain on the south side of Loch Assynt, towards Canisp, exhibits the same arrangement. The gneiss on the west side is overlaid by nearly horizontal sandstone beds, which are in turn covered unconformably by quartzite, sloping down to the east at 20° to 30°. The relation of the quartzite to the gneiss, bounding it on its eastern side, was not visible on the line we followed, as a mass of red felspar-porphyry intervenes near Loch Borolan. This rock is not unlike some portions of the Loch Broom serpentine, thus adding to the analogy of the two sections†.

On the north declivity of Queenaig the quartzite again appears, resting unconformably on the red sandstone; but the relations of the formations are obscure, probably from some fault near the line of junction. In Loch Glencoul the superposition of the quartzite to the red sandstone is very distinct, and both rocks are seen dipping away under the huge mountains on the east. In the recesses of this loch,

* Probably it is only the lower quartz, brought up anew by a fault.

† Mr. Cunningham states, p. 96, that the quartzite of Ben More rests unconformably on the gneiss. The relations of this quartzite, both to the gneiss and to the limestone of Stronchrubie, require further investigation.

which we did not explore, Mr. Cunningham describes the gneiss as resting conformably on the quartzite and limestone. The same observer also figures and describes a very singular instance of this remarkable relation on Loch More. His section shows a lower highly inclined gneiss, covered unconformably by an ascending series of quartz-rock, limestone, and gneiss, all conformable to each other.

The next locality which I shall notice is the vicinity of Durness, where the limestone is distinguished by containing organic remains in considerable abundance. The general relations of the rocks are shown in fig. 4. The western shore of the Kyle of Durness consists partly of gneiss, partly of the quartzite in thin even beds, some of them full of the cylindrical bodies, but often more branched and coral-like in their forms than either at Assynt or Ullapool. This rock dips at 20° to S. 60° E., and, on the road to Cape Wrath Lighthouse, overlies red sandstone and conglomerate, dipping unconformably at a lower angle (10° N., 25° E.). The red sandstone exhibits no peculiarities, the lower bed being a not very coarse conglomerate of slightly rounded fragments of quartz and red or white felspar, in a reddish-yellow basis of sand. Mr. Cunningham noticed the quartzite in this place alternating with "strata of slate-clay of a character little differing from that which is associated with the red sandstone of the coal-series*." On the east side of the Kyle the low country is chiefly limestone. On the shore near Balnakiel House, where it contains the fossils, it dips at 10° E., but in one place folds over in a low arch. The principal mass is of a dark-blue colour, very hard and siliceous, striking fire readily with the hammer. It contains large lumps of reddish-brown chert, with innumerable flinty concretions of singular forms; and, when weathered, the surface has a peculiar rough aspect, as if covered with broken corals or shells. Other beds are of a light-grey colour, and more arenaceous texture; and others again more argillaceous, and divided by a kind of cleavage into laminæ from a quarter to half an inch thick. In general aspect it closely resembles some of the carboniferous limestones where altered by trap.

Beyond Durine, the limestone still dips east, but at a higher angle (20° to 25°), and alternates with beds of a more arenaceous character. Beyond the Smoo Cave it is cut off by gneiss in nearly vertical beds, with a W.N.W. direction. This rock forms the ridge running south-west from near Rispond to the Gualin. The eastern declivity of these hills is, however, covered by the quartzite, sloping down in vast beds to Loch Eriboll, and in some cases extending to the tops of the mountains. Many parts of this quartzite are soft, almost friable sandstone, not harder than the common grits of the coal-formation. The low ground on the eastern shore of Loch Eriboll, and the under declivities of the hills, are of limestone, in some places overlaid by a similar arenaceous quartzite. In the hills above Eriboll House this limestone series is overlaid by gneiss, which also dips south-east towards Loch Hope. The infra-position of the limestone to the gneiss in this locality has been recognized by many observers, from the time

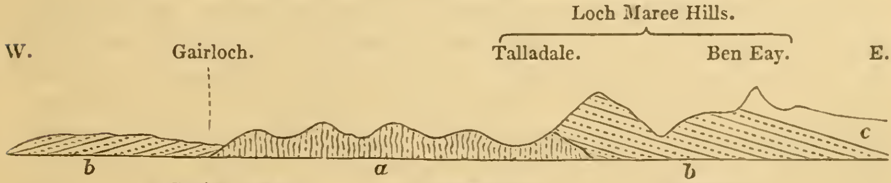
* Essay, p. 92.

of Dr. Macculloch, who, in his 'Western Isles,' described it, and gave a section, in which however the gneiss of Rispond is represented as conformable to the quartzite and limestone. Professor Sedgwick and Sir R. Murchison in 1828, and the latter again in 1855, when we examined the section in company, and Mr. Cunningham in 1839, have all come to the same conclusion. It must also be observed, that the superiority of the gneiss to the limestone is not seen in one place only, or in sections of a few yards' extent, but along the whole escarpment, from the sea-worn precipices of Whiten Head* to the picturesque Craig-na-Feulin, at the extremity of Loch Eriboll, a distance of more than ten miles in a straight line.

In this line of traverse there is one fact of considerable importance: the red sandstone which on the west side of the Kyle underlies the quartzite, and becomes far thicker and more extensive in the Parph Hills to the west, does not reappear on the east side of Durness or on Loch Eriboll. The quartzite there rests immediately on gneiss, the red sandstone having thinned out. To this remarkable feature we shall have again to refer in noticing the sections further south.

Sections in the Southern part of the District.—Returning from the extreme north, I shall now describe some sections in the range of the red sandstone and quartzite in the country south of Loch Broom. The interior of Loch Greinord is all coloured as gneiss by Macculloch, but consists partly of true gneiss, partly of a singular dark or light green rock, which appeared to me rather a serpentine or syenite, enclosing large angular fragments of gneiss. It forms a group of round-topped conical hills, with smooth, bald summits, destitute of all vegetation, which, though of no great altitude, have yet a remarkably wild and rugged aspect. From this place the gneiss appears to extend, in many peculiar varieties, continuously across the foot of Loch Maree to the Gairloch. Red sandstone, however, forms the outer headlands, and is well exposed on the shore of Loch Greinord, towards the Rumor, dipping at high angles, and covered unconformably by beds of a newer red sandstone†. At Gairloch and on Loch Maree the sandstone is well seen, and its relations, both to the inferior gneiss and to the quartzite, are very distinct, as shown in the accompanying section, fig. 5. The lowest rock is

Fig. 5.—*Section across Gairloch and Loch Maree.*



a. Gneiss (lower). *b.* Red Sandstone. *c.* Quartzite.

* I did not visit Whiten Head, but both Dr. Macculloch and Mr. Cunningham mention the section.

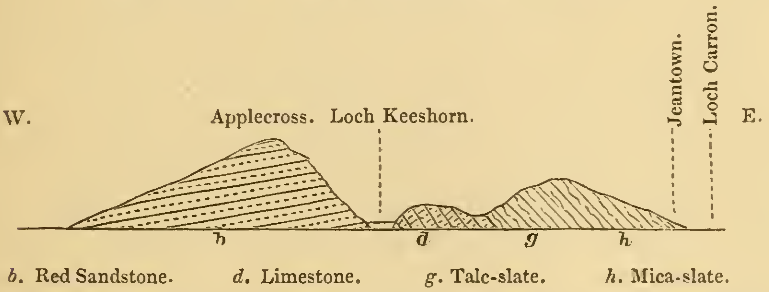
† According to Macculloch, the only undoubted New Red Sandstone in Scotland.—Memoir on Map, p. 94.

the gneiss, forming the rugged rounded hills between the Gairloch and the lower half of Loch Maree. The gneiss is in general of a light or dark grey colour, and finely granular; but other varieties are reddish, and more perfectly crystalline, or, again, contain distinct granular concretions of quartz or small garnets. Interstratified with it are beds of mica-slate, or fine-grained hornblende-slate. The strata are often contorted; but the general direction is nearly parallel to Loch Maree, or about N.W. (from N. 40° W. to N. 60° W.), and the dip almost vertical, or inclining to the south-west. The next rock is the red sandstone; the lower bed, where in contact with the gneiss, as on the shore near Gairloch Kirk and on Loch Maree, being a very remarkable breccia of quartz and gneiss in sharp angular fragments, not at all rounded or worn. The quartz is white and vitreous, or red and ferruginous, or a kind of blue hornstone,—the gneiss often like the finer varieties below. The largest fragment I saw measured sixteen inches long, by nine broad, and seven thick; but the generality are much smaller. In no place could I find any granite in this breccia. Above the breccia coarse gritty beds occur, interlaminated with finer materials; some of them almost a light-red, fine-grained quartzite. The breccia is everywhere exceedingly hard, and in many places closely resembles the gneiss; so that the broken, turned-over ends of the gneiss appear to pass almost imperceptibly into the sandstone. On the outer headlands, the red sandstone dips to the west or south-west, and forms a low undulating country, with the outcrop of the beds projecting through the moor. On Loch Maree the sandstone first appears as mere fragments of the coarse breccia, stuck in among the ends of the vertical red or grey gneiss. Near Talladale it becomes continuous, resting on, and as it were embossed in the hollows of, the gneiss hills. In mineral character it presents few peculiarities, except that a false bedding or lamination is not uncommon. From the uneven surface of the beds and the low angle, the dip is uncertain, but is about 10°–15° to S., 25° to 30° E. In the mountains on the south-west of the lake, the white vitreous quartzite is clearly seen overlying the red sandstone, and often projecting in a kind of terrace on the side of the hill. In some of the lofty summits near Ben Eay, darker beds again rest on the quartzite, perhaps the equivalents of the grey siliceous beds of Loch Broom.

The red sandstone in this district has undergone enormous denudation. On the shore of Loch Maree it is often broken up into huge masses, or divided by gaps and fissures, some of them still twenty to thirty feet deep, though only a few (10 to 20) inches wide. The surface of the beds, too, is strewed with immense angular and ruin-like blocks, some of them poised on a single corner on the very edge of a cliff. All this indicates extensive destruction of the strata; and other proofs of the fact are not wanting. Detached fragments of the breccia are found in hollows of the gneiss hills far from the main masses, and evidently left in the general denudation. Several of these fragments appear on the shores of Loch Maree, and many of the beautiful wooded islands sprinkled over its surface are of the same nature. All these evidently have once been continuous, and the red sandstone must have filled the valley of this most magnificent of Highland lakes, as deep as the lofty summits of Sleugach and Ben Eay, and have all subsequently been hollowed out and removed. The western hills, towards Gairloch, are still strewed with innumerable fragments of red sandstone, perched, like sentinels, in the most exposed and perilous positions, on the very edge of some lofty cliff, or on the polished summit of the domes of gneiss*.

The red sandstone of Gairloch extends continuously into Applecross; and the whole of this vast formation must, therefore, be older than the quartzite. I examined the relations of the two deposits on Loch Keeshorn, in 1855, with Sir R. Murchison, and the section (fig. 6) represents the facts as seen by us. The great

Fig. 6.—*Section across Loch Keeshorn.*



mountain-district of Applecross consists entirely of red sandstone rising in terrace above terrace from the shore of the loch and valley. The general characters of the sandstone correspond to those already noticed; and, as a detailed section has already been given by Sedgwick and Murchison, need not be repeated here †. On the east side of the valley an entire change takes place in the rocks. The low green hill consists of limestone, of a light-blue colour, becoming white when weathered, and with the peculiar, fine-veined brecciated structure characteristic of the limestones of Ullapool, Assynt, and Durness. We examined this rock carefully for organic remains, but without success. The red sandstone dips at 10°–12° to W.S.W.; the limestone, in broken irregular beds, at a higher angle to the east. The narrow glen, followed by the Jeantown road, exhibits a series of talcose slaty rocks, some of a light-yellow, others of a dark-green colour, dipping at 45° E.S.E. (E. 20° S.) in thin even beds. These beds seem to overlie the limestone, though no immediate junction of the formations was seen. The relation of the limestone to the red sandstone of Applecross is more doubtful. The more natural interpretation would be that the sandstones had been deposited on the ends of the upturned limestone beds, and subsequently partially removed by denudation; but the

* It is a curious fact, that on these gneiss hills by far the majority, probably nine-tenths or more, of these "perched blocks" are red sandstone.

† Geol. Trans. 2nd Ser. vol. iii. p. 154.

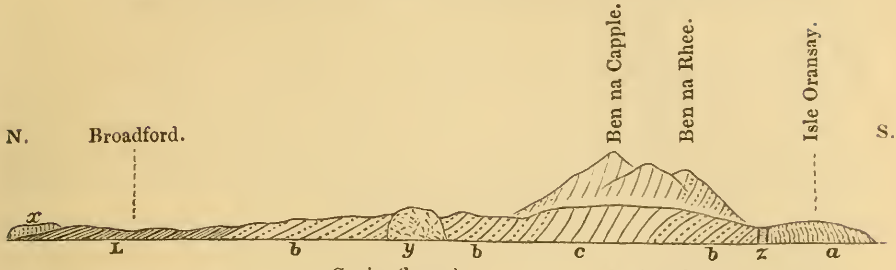
relations established at Gairloch and further north demand that we should regard the valley as a line of fault, bringing down the limestone beds to a lower level than the sandstones on which they were deposited. The sandstone, too, seems to have been thinning out here to the east, as the lofty mountains in the interior, seen both from Loch Keeshorn and on the road from Loch Carron to Auch na Sheen, appear to be capped only by the quartzite, covered in some places by darker beds, but without the red sandstone below.

The section from Kyle Aken Ferry to Balmacarra, and thence to the mountains of Kintail, appears to confirm these general relations. The red sandstone which occurs near the Kyle dips east under a peculiar group of slaty rocks, the representatives, according to Macculloch, of the quartzite series. It consists of blue or grey clay-slates and coarse grits, made up of quartz, felspar, and fine scales of mica, the whole in many respects not unlike some portions of the Silurian strata in the South of Scotland. The stratification is very well marked, and the beds are also intersected by distinct planes of cleavage—one set parallel to the bedding, others oblique at various angles. This group of rocks dipping E.S.E. continues to beyond the inn, but before reaching Loch Ling several veins of red felspar-porphyry interrupt the succession. Near Dornie Ferry a large mass of dark-green dioritic serpentine forms some low hills or knolls. Near Totaig, on the south side of Loch Duich, an irregular broken and fissured bed of white crystalline limestone, mixed with actynolite, pyrite, and other minerals, occurs in connexion with a similar igneous rock or a syenite. Other larger masses of limestone crop out on the north-east shore of Loch Duich, probably in two or more courses, and dip at a high angle (50°) to the south-east. These limestones are connected with the true metamorphic rocks of the country; but it is impossible to avoid remarking that their proximity to the quartz series, and the great rarity of limestone in the gneiss of the north-west of Scotland, give some probability to the view that they may be only a more highly altered portion of the quartzite dipping under the great mountain group of the Bealloch of Kintail *.

Skye.—At this point, the great bands of red sandstone and quartzite terminate on the mainland, but, according to Dr. Macculloch, are continued through the district of Sleat in the south of Skye. This observer describes the relations of the rocks in that tract as exceedingly complex, and the sections drawn in his work on the Western Isles by no means lessen the difficulty. The section (fig. 7) from Isle Oransay to Broadford intersects the whole formations, from the gneiss on the one hand to the newer secondary deposits on the other. On the south coast at Isle Oransay, the gneiss, sometimes hornblendic, is seen dipping south-east towards the mainland. On the north of it, a mass of claystone, or felspar-porphyry, occurs in a depression partially filled up by detritus concealing the rocks. Beyond

* It is worthy of notice also, that in these mountains granite first appears in mass, on the west coast, in the whole range from Cape Wrath to the south.

Fig. 7.—*Section through the southern part of Skye.*



L. Lias.
a. Gneiss (lower).
b. Red Sandstone.
c. Quartzite.
x. Porphyry.
y. Syenite.
z. Clay-stone-porphyry.

this hollow, red sandstone and conglomerate beds appear, at first broken and disturbed, but soon dipping regularly to W.N.W. at angles ranging from 25° to 40°. The sandstone is of a reddish-brown colour, with thin yellowish layers of finer materials, but is much hardened and altered, and at first sight might easily be mistaken for gneiss. In many respects it closely resembles the beds above the coarse breccia at the Gairloch. At the head of Loch Daal the sandstone is followed by thick beds of greyish quartzite, dipping N.W. at 20°. Further north, beds resembling greywacke, with light-yellow and blue slates, follow, dipping at 40° to 60° W.N.W. These beds have the general character of the Balmacarra slates, but are softer, and without cleavage. In Ben na Rhee and Ben na Capple, on the east of the road, the beds appear to dip at a much higher angle, and to be more quartzose in character. The next higher group of strata is again red sandstone, but lighter in colour, and softer than the sandstones below the quartzite. The syenite or felspar-porphyry of Ben na Charn interrupts this series, but without altering the direction of the dip. On the north of the igneous rock, the sandstone is of a whiter colour. On Broadford Bay the lias shale and limestones, full of *Gryphææ*, *Ammonites*, and other characteristic fossils, appear dipping 8° N. 50° W., and intersected by the most complex groups of trap-veins. Beyond Broadford Bay the lias is covered by beds of green-coloured columnar porphyry, both the igneous and stratified rocks being again intersected by vertical veins of grey greenstone.

This section, though the lower rocks are clearly identical, differs in many important points from those formerly described. The dip of the beds is now to the N.W. instead of to the S.E., as on the mainland. The quartzite is no longer the white granular quartz-rock of the northern sections, but in many parts rather a greywacke or slate. The limestones do not appear in the section, but the quartzite is now covered by soft red or white sandstones, and these by the shales and limestones of the lias, instead of the hard metamorphic gneiss of Ullapool and Loch Eriboll. The lower red sandstone is evidently the same rock with that seen on the mainland, and the quartzite may also be probably identified, though somewhat different in characters. How far the upper red and white sandstones belong to this group is more doubtful.

Order of succession.—This review of the red sandstone and quartzite as they appear in the long course of more than 100 miles along the west coast from Durness and Cape Wrath to Loch Alsh and Skye establishes the following important facts in the geology of this part of Scotland.

First. The red sandstone is the lower formation, resting only upon gneiss, and forming a narrow band along the western shore, never reaching to the watershed of the country, and not exceeding twenty miles in breadth in its widest portions, as on the Gairloch.

Secondly. The quartzite is a distinct and newer formation, resting unconformably on the red sandstone on the west, but on the east spreading out beyond it over the gneiss. Its present breadth, including outlying portions, does not exceed ten miles, and is generally much less. The limestone forms the upper portion of this band.

Thirdly. That the general dip, though at a different angle, both of the red sandstone and quartzite is to the south-east; and that at many points on its eastern side the quartzite and limestone have been ascertained to dip under gneiss inclined in the same direction.

Organic remains.—This inferiority of a vast series of sedimentary deposits—for what is true of the quartzite must be true also of the red sandstone on which it rests—to a highly metamorphic rock like gneiss has acquired additional interest from the discovery of undoubted organic remains in some of the beds. These remains I shall now notice in the order of the formations. In the red sandstone no organic remains have been found, partly perhaps from the nature of the beds, partly, we may presume, from the few opportunities they present, from quarrying or other operations, for their discovery. In the quartzite probable indications of organic beings are more numerous. In his first Memoir on Quartz-rock, published in 1814, Dr. Macculloch noticed the "imbedded cylindrical bodies" seen both on the surface and in the interior of the quartzite, and described them as "the remains of some animal, a *Sabella* or other marine worm." The organic origin of these bodies has subsequently been denied, but as it appears to me erroneously. Consisting entirely of sand—and thus rather casts than petrifactions—they can scarcely be expected to show any structure, so as to decide positively their true character. Their branched forms and their immense numbers, closely crowded together over wide spaces, are opposed to the view that they are the mere burrows of marine worms, as Macculloch suggested. Both in general aspect and mode of grouping the cylindrical forms much resemble the *Lithodendron* corals, whilst the conical, rounded or polygonal bodies in other beds have more similarity to *Cyathophyllæ*. I shall, however, leave to further investigation to determine their true nature, as at present we can draw no argument from them in regard to the age of the strata.

In other beds of the quartzite, I have mentioned plant-like impressions as occurring in abundance. But these are in general nothing more than a confused mass of carbonaceous markings, more like fucoids than any higher forms. This, however, seems to have arisen in part from the changes the rocks have undergone, as we occasionally find straight, cylindrical fragments, like stems or branches of trees, 2 to 4 inches in diameter and 12 to 14 inches long. Some of these are marked with obscure scars, as of leaves or branches. Round or oval markings, like those on the *Stigmaria* of the coal, are also not uncommon, scattered irregularly over the surface of the rock. On a few specimens they were arranged quincuncially, as on the Stigmaria; but, from the imperfect nature of the specimens, I would not place much weight on this mere resemblance, though the indications of a higher terrestrial vegetation at this period are of much importance.

In his 'Western Isles,' Dr. Macculloch mentions his discovery "in a porous or incompact granular quartz, alternating with the limestone," on Loch Eriboll, of "conical bodies not exceeding a quarter of an inch in length, being evidently the fragments of Orthoceratites or some analogous fossil, possibly entire shells *." These bodies have subsequently been noticed by other observers; and in 1855 Sir R. Murchison and myself found them in considerable numbers. The best-preserved specimens are, as Macculloch states, of a conical form, about a quarter of an inch long, and on the cross fracture show that they have been hollow at the broader end. Their minute size, and the nature of the stone in which they are imbedded, and from which they cannot be separated, render their character uncertain. The want of septa, of which I can discern no trace, shows that they were not Orthoceratites; and if shells, I should regard them rather as belonging to small Pteropod mollusca.

By far the most distinct fossils, however, are those found in the Durness limestone, for the discovery of which we are indebted to Mr. Charles Peach. When I visited this place in company with Sir R. Murchison, we found these fossils in considerable abundance, both in the beds described by Mr. Peach, and in others at a lower level. They are principally seen on the surface of the rock where wasted by the sea or weather, but the hard refractory nature of the stone renders it almost impossible to extract them in a state fit for description. The results of a careful examination of these fossils are thus stated by Sir R. Murchison. "It had been suggested that the fossils in question, being of a whorled form, might prove to be the *Clymeniæ* of the Devonian rocks; but although, according to Mr. Salter, one or two of them have a certain resemblance to that genus, and some even to *Goniatites*, the evidence of their being chambered shells is too obscure to decide the case. The principal fossil is probably a *Euomphalus*: it resembles the *Maclurea* or *Raphistoma* of the Lower Silurian rocks, except that the former, to which it most approaches, has a sinistral and not a dextral curve. Even should some of these whorled shells prove to be chambered, there is nothing about them to gainsay their belonging to the *Lituites*

* Vol. ii. pp. 512, 513.

of the Lower Silurian rocks. Another fossil is certainly an Orthoceratite" *.

I may further remark, that many of the singular forms brought out on the surfaces of this limestone by weathering are probably, as Dr. Macculloch long ago conjectured, of organic origin; "in particular the red vermicular forms very similar to many that occur in the well-known marble of Babicomb." I have little doubt that these are truly corals. Better and more determinable specimens will probably yet be procured from some of the less altered beds of this series; but in the mean time the question arises, To what geological period do these organic remains belong? What age do they indicate for the beds in which they are found? The only certain genera are the *Orthoceras* and *Euomphalus*, but these characterize rather the Palæozoic beds in general than any of the formations in particular. The mere resemblance of others to *Lituites*, *Clymeniæ*, or *Goniatites*—to Silurian, Devonian or Carboniferous forms—is too uncertain a foundation on which to build any argument. Beyond the mere fact, therefore, that these formations belong to the great series of Palæozoic strata—and this fact is one of very high importance,—I do not think that these organic remains will as yet safely carry us.

Distinctive physical characters.—Being thus, as it were, thrown back on the general characters and relations of these deposits, the question arises, Do they furnish us with any aid in determining their age? The red sandstone has hitherto been generally regarded as of Devonian age; and so strongly are the characters of this formation, as seen in other parts of Scotland, impressed on it, that we may affirm no doubt would ever have existed on the question, except from its relation to the quartzite †.

As it is now proved to lie below the quartzite, its age must evidently be affected by our views regarding the latter rock, which, as I have shown, is a distinct and newer formation. Now the close analogy of this group to the mountain-limestone and associated sandstones, has forced itself on every observer, and in describing it comparisons with the coal-formation in the central districts of Scotland constantly recur. The mineral characters of the beds are almost identical—more so indeed than we might have expected, considering the distance of the localities and the changes the northern deposit has undergone. It consists of fine- or moderate-grained white siliceous sandstones, not harder than many in Fife or the Lothians in the vicinity of trap; disposed in regular beds of moderate thickness, with ripple-marked surfaces and false stratification; of thinly

* Brit. Assoc. Report for 1855, Trans. Sect. p. 87. In addition I may mention, that a specimen of Orthoceratite, which I procured from these beds, measures 1·4 inch in length, with a diameter of ·4 at the upper and ·2 at the lower end. It is somewhat compressed, and quite smooth on the external surface.

† Dr. Macculloch seems to have been inclined to regard it as a primary red sandstone; Mr. Cunningham named it "Transition." Professor Sedgwick and Sir R. Murchison in 1828 classed some portions as "Primary," others as "Old Red."

laminated, blue or grey shales, full of carbonaceous, plant-like impressions, and strongly impregnated with iron ;—and lastly, of blue or grey limestones alternating with shales, and in some places black, bituminous, and emitting a "fœtid odour similar to that detected in various mountain-limestone strata." Even the external features of the fine cliff of Stronchrubie, with its beds of limestone, sandstone, and trap, are entirely those of the coal-formation : whilst those of the quartzites of Ben Spiannue and Loch Eriboll are just those of the sandstones in the south of Scotland or north of England. Now though the occurrence of one of these beds or groups alone—of a red sandstone and conglomerate, of a white sandstone and shale, or of grey and bituminous limestone—would furnish no strong indication of age, yet the coincidence of the whole three in their proper order is a far more powerful argument. It seems highly improbable that in such a limited region as Scotland there should have occurred in the palæozoic age two such complex series of deposits, so nearly identical in mineral characters and order, and yet that they should not be contemporaneous.

The chief objection to assigning so recent a date to these quartzites and limestones is the remarkable fact, that on the east they dip below gneiss. Now the gneiss of the central region of Ross and Sutherland, dipping, with few exceptions, continuously to the south-east, is observed passing under the Old Red Sandstone of Ross-shire and Caithness. This clearly appeared in three traverses of this region, from the east to the west coast, which I made in company with Sir R. Murchison in 1855, and is indeed admitted by the most competent observers*. If, therefore, this gneiss, that overlies the quartzites of the west coast, is truly a portion of the great formation of the central regions which underlies the Devonian rocks on the east, and has been originally deposited and metamorphosed in the place where it occurs, it seems necessarily to throw the red sandstones and quartzites of the west coast into a much earlier geological period,—most probably into the Lower Silurian. This continuity of the overlying gneiss of the west with the underlying gneiss of the east coast has, however, not been established, and would indeed be a work of great difficulty in such a wild and pathless country. In those parts of Ross-shire, also, where the quartzite directly overlies gneiss, it is evidently the lower gneiss of the same age with that on the west coast of Sutherland, that forms the surface. The fact also of the overlying gneiss having been metamorphosed *in situ*, and not pushed up over the quartzite, is one requiring further investigation. The occurrence of igneous rocks—syenitic porphyries or serpentines, at many points along the line of union, seems to indicate a fault. On the other hand, the great extent over which this relation has been observed, of fifty or a hundred miles, is unfavourable to the view that it is the result of a slip or convolution of the beds. The quartzite also and the limestone have undergone

* "It is generally, but not universally true, that the dip [of the gneiss] is to the south-eastward."—Macculloch, Mem. on Geol. Map of Scotland, p. 63. See also the dips laid down on Mr. Cunningham's Map of Sutherland.

great metamorphic action, which seems to have less affected the upper portion of the red sandstone; whilst the bottom beds of the sandstone again, as on the Gairloch, have been exposed to it in a much higher degree. In other words, the red sandstone and quartzite appear to have been more affected at the two extremities, above and below, than in the middle of the series*.

Probable Age.—On the whole, therefore, though all doubt can only be removed by the discovery of better-preserved characteristic fossils, I regard the theory, that the red sandstones of the West Highlands are of Devonian age, the quartzite and limestone of Lower Carboniferous, as the more probable. Whether we consider the gneiss resting on the latter as a newer metamorphic group, or merely as a portion of the lower gneiss forced up over it in some great convulsion, we have still views of very great interest opened up to us in the history of these Highland mountains. They can no longer claim that remote geological antiquity which has hitherto been assigned to them, but belong, at least in their present form, to a far more recent period in the history of the earth,—to one posterior to the deposition of the horizontal coal-fields and sandstones of the south.

In offering to the Society, first a statement of facts, and then my views of the probable age of the quartzites and limestones, I wish it, however, to be understood that my Memoir has reference only to the north-west coast of Scotland. How far it may apply to the quartzites of other parts of the Highlands must be left to future consideration. It is also clear, that these facts in no way affect the accuracy of the Devonian classification of the great ascending triple series of the east coast,—of the coarse conglomerates and red sandstones, the dark bituminous Caithness flags, and the overlying red sandstones of Dunnet Head and the Orkneys,—as established by Sedgwick and Murchison in their most important memoir. I am fully convinced that Scotland contains red sandstones and conglomerates of various dates; and should it ultimately prove that the quartzite and limestones now under consideration are of Silurian age, I shall deem it no small matter to have established, as the facts now stated would then clearly prove, that the red sandstones of the west coast belong to a far different period from the corresponding rocks on the east, with which they have hitherto been identified.

Geological History of the North-western District of Scotland.—Before concluding, there are a few considerations on the succession

* I have not referred in the text to Mr. Hugh Miller's views of the age of these beds, as I am not aware he has ever fully published them, except in an article in the 'Witness' newspaper printed before the discovery of the fossils by Mr. Peach. He appears to consider the whole as Devonian,—the red sandstones representing the lower conglomerate, the limestone the middle calcareo-bituminous flags of Caithness, and the quartzite the upper red sandstones of Dunnet Head. My reasons for not adopting this classification will be readily suggested by the text. [The lamented death of this distinguished geologist offers another reason for not controverting a theory which he is no longer spared to defend.—J. N. January, 1857.]

of geological phænomena in this portion of Scotland which I would wish to introduce. The oldest formation is undoubtedly the gneiss seen underlying the red sandstone, from Cape Wrath to the Gairloch and Skye. Its chief mineralogical peculiarity is the prevalence of hornblende and the comparative rarity of mica, though the more ordinary kinds are far from being unknown. Though granite-veins often intersect this rock, there is no mass of granite which can be assigned to this first period. Indeed the fragments in the red sandstone, and the composition of its grits, would lead us to conclude that granite was not an abundant rock in this region, more especially the regular compound of quartz, felspar, and mica, which appears to have been chiefly formed at a more recent period*. This older gneiss, in the region indicated, has a general direction to the N.W., apparent not only in the strike of the rocks, but also in many of the lakes and valleys. In the mountain ranges this direction is far less marked, having, it appears, been obliterated by subsequent denuding action.

Over the gneiss thus elevated, a large deposit of red sandstone has been thrown down. Where the bottom beds are a coarse angular breccia, intercalated amidst the broken ends of the gneiss, as on the Gairloch, the deposition of this rock must have immediately succeeded some violent convulsion, either local or general. The red sandstone on the west forms a narrow band along the shore, and never extended far into the interior; still less over the whole country, as has often been imagined. This is proved by its thinning out on the east, below the quartzite; whilst the conglomerates on its margin in Caithness and Easter Ross also appear to indicate proximity to the shore on that side of the island. The thickness of this deposit must be very great,—from 2000 to 3000 feet being still exposed in the mountains of Applecross, Gairloch, Loch Broom, and Assynt, whilst the dip of the strata implies that its original dimensions were far greater.

At the close of this period the country must have been still more depressed towards the east, allowing the quartzites to extend much farther into the interior. At present the quartzite-fragments unconnected with the red sandstone stretch from five to ten miles beyond its boundary, but may probably have once reached much farther over the gneiss. A change in the mineral character of the deposits also took place, the red sediments ceasing and others more favourable to organic life coming in their place, as shown in the fossiliferous limestone above. The quartzite including the limestone has no great thickness, probably not exceeding from 300 to 500, or at most 800 feet. To this, however, must be added the quartzite of Ben More Assynt, if truly overlying, and also the upper gneiss, so far as this has been metamorphosed in place.

* Micaceous granites are also rare in the Old Red Conglomerates in many parts of Scotland, and the granite-boulders in the Silurian conglomerates on the Ayrshire coast rarely contain this mineral; thus showing that they have not been derived from the granite-mountains in the vicinity, but from an older formation.—See Murchison on the Silurian Rocks of Scotland: Journ. Geol. Soc. vol. vii. p. 153.

The termination of the quartzite-period seems again to have been marked by convulsions. To these we must ascribe the action by which the higher portions were converted into gneiss; or this gneiss, if a pre-existing rock, forced over the quartzite. At the same time we may suppose that those serpentinous felspar-rocks were formed which we have mentioned as occurring at Loch Alsh, Ullapool, and Assynt, and which probably exist in other places. In the same period also we may place the serpentinous rocks mixed with the gneiss of Loch Greinord. The effect of this action has been to raise up the strata along a N.E. and S.W. line, running nearly parallel to the west coast, from a point between Cape Wrath and Durness on the north, by Loch Greinord and Loch Keeshorn, to near Kyle Rhea in Skye. The red sandstone dips west from this axis on the west side, and on the east side east, with all the superior strata. The watershed of the country is a parallel line, but lies much farther in the interior; and the influence of this line of elevation may also be traced in many other physical features of the north-west Highlands*.

The next great action to which this region was exposed has been that process of denudation by which the mountains have been cut out into their present forms. If the newer red sandstone on Loch Greinord be, as Macculloch supposed, red marls or triassic, this action must have begun shortly after this elevation, as it is chiefly made up of fragments of these older strata. At the same time, or soon after, the lias of Skye may have been forming in the deeper and more distant parts of the sea. But at whatever time this denudation took place, we may form some idea of the manner in which it was effected. The whole west coast seems to have been slowly and uniformly rising, until it stood like a long mural ridge above the waters. But these waters were not idle,—breaching this rampart from point to point along the old lines of fracture, and hollowing out those great sea- and land-lochs by which the country is now intersected. Even after this process was completed, the elevation seems still to have gone on,—carrying the mountains far up into the regions of ice and snow, when those enormous glaciers were produced which filled their deepest valleys, and polished their hardest rocks, from the sea-level to many hundred feet above it, as with a lapidary's tool.

But the land must have again gone down, even below its present level, leaving only the mountains, like islands, rising up out of the ocean. In no other way can we explain the peculiar forms of the low rounded gneiss hills between Loch Enard and Loch Inchard, and the singular detritus with which they are covered. The innumerable islands lying off the coast of Edderachyllis are only a portion of such

* These two lines of elevation which I have thus noted in the rocks of this region, it will be observed, correspond with two of the most ancient lines described by M. Élie de Beaumont, in his "Notice sur les Systèmes de Montagnes." The N.W. line may be referred to the system of Morbihan, which at Milford has the direction of W. 36° 35′ N.; the N.E. line to the Longmynd System, with a direction N. 21° 24′ E. at Milford. The order of succession is not, however, the same, and my observations are not sufficiently numerous to make a more precise comparison worth while. So far as they go, these coincidences may be regarded as favourable to the more ancient date of the beds.

land, not yet raised out of the ocean. At this time, too, has taken place the transport of those innumerable "perched stones" which we have noticed throughout all this region, apparently floated away on icebergs from the mountains on the east, and deposited on the tops of the lower hills as they again rose above the waters to their present elevation.

It is an important fact in connexion with all these great and repeated changes of level, that this district is remarkably free, for Scotland, of igneous rocks. No large masses of any of them are seen at the surface, and even veins are by no means common. The granite-veins at Cape Wrath, and near Lochs Inchard and Laxfiord, are the most important exceptions; and then the porphyries and serpentines of Assynt, Loch Broom, and Loch Greinord. Trap-veins occur rarely in Assynt, but seem scarce known on the main-land, either to the north or to the south. This is the more remarkable when we consider the proximity of Skye, where these rocks, of many different ages, are so fully developed; or contrast this part of Scotland with the west coast of Argyll, where they break out almost every hundred yards.

It thus appears that this portion of Scotland has formed a peculiar isolated region, even from an early period. Perhaps a still more important lesson to the geologist may be found in the fact, that changes so singular in character, and so immense in extent, have taken place in this country, and yet almost no trace of the powerful agent by which they were effected appears on the surface.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On the Newer Tertiary Deposits *of the* Sussex Coast. By R. Godwin-Austen, Esq., F.R.S., F.G.S.

[Read November 7, 1855*.]

Contents.

At the Meeting of the British Association held at Ipswich in 1851, I called the attention of the Geological Section to the evidences of repeated oscillations of level of no remote date, which were to be observed in parts of the coast of Cornwall, Devon, the Channel Islands, and the Cotentin—an area comprising the western opening of the English Channel†. I was fully aware that like changes were to be traced round its eastern extremity, but many circumstances tending to render the evidence less distinct in that direction, the subject was reserved for separate consideration.

§ I. *The land bounding the eastern portion of the English Channel.*

English Coast.

Dorset and Hants.—It will be seen, by reference to any geological map of England, that the great bay west of Portland corresponds

* For the other Communications read at this Evening's Meeting, see Quart. Journ. Geol. Soc. vol. xii. p. 1 &c.

† Several papers by the author, relating to the English Channels and the superficial accumulations along its coasts, and on the drift-gravels of the south of England, may be referred to in the Quart. Journ. Geol. Soc., vol. vi. p. 69; vii. p. 118 and p. 278; xi. p. 112. See also papers by Sir R. Murchison on the Flint Drift, *op. cit.* vol. viii. p. 349; Mr. Trimmer on theErratic Tertiaries, vol. ix. p. 282; and Mr. Martin's paper, vol. xii. p. 134.

exactly with the breadth of the series of yielding oolitic strata, along which line the rate of destruction and removal is now so great as to warrant the supposition that this particular portion of the south coast has been mainly produced within a comparatively recent period. Weymouth Bay is partly due to a line of depression and partly to sea-waste. From Portland to Durlston the coast-line presents advancing cliffs of hard strata; but, whenever yielding beds come in, as to the east of Swanage, the coast-line recedes. At some time therefore, not very remote, the line of this part of the south coast of England must have been less irregular, or more linear in an east and west direction than at present.

The remains of Elephants and other large Mammalia occur in all the valleys which open out into Charmouth Bay, from the Exe to the Brit; the gravel-beds in which these occur are much above the present sea-level, and have been cut through, at some time subsequent to their original accumulation, along the central lines of these valleys. These valley-gravel-beds are quite distinct from those, with pebbles of quartz and granite, which cap the Haldon, Blackdown, and other ranges which run down to the coast as far east as the Bridport valley, and which gravel-beds do not contain mammalian remains.

The beds of peat with timber-trees which are to be seen at *low water* opposite the openings of some of these valleys, as at the mouth of the Char, must not be taken as indications of recent changes of level, but only as serving to mark the continuation of those valleys before the coast-line had been cut back. A little caution is necessary with respect to numerous local deposits of a terrestrial character which are exposed *between* tide-levels round the whole of the east end of the English Channel, but I am not aware of any special character by which these accumulations can be distinguished from those older land-surfaces which were coeval with the large Mammalia, and older than the gravels containing their remains.

The accumulations of shingle on this part of our coast consist principally, as in the great Chesil Bank, of chalk-flints and chert; but it is deserving of notice that the so-called "raised beach" at Portland Bill is mainly composed of local materials, *and with only a few flints:* so that, at the time the water-level stood at the line thus indicated, materials were not available for flint-shingle as at present: the cause of this must obviously be sought for in the change of level itself.

The flint-shingle of the beaches of Studland and Christ Church Bays is derived from the gravel-beds which cover the adjacent parts of Dorset and Hants: this is the case with respect to the shingle-beaches of the whole of the eastern extremity of the English Channel,—the great bulk of the material is *old gravel*, which has been worked over again and again during various successive periods.

Some peculiar features in the parts of the Isle of Wight and South Hants, bordering the Solent, will be noticed in the sequel.

Sussex.—Further east, the Chalk Downs of Sussex present a ridge from three to six miles broad, trending from Beachey Head in a direction about E. by S., W. by N.; from this headland to Selsea

Bill, the coast-line lies due E. and W., so that there intervenes a tract between the chalk-range and the sea, which ultimately acquires a width of ten miles, as from Lavant to Selsea; this tract is low and level, and presents the series of superficial accumulations which will be here described.

The escarpment of the chalk-range which overlooks the Weald is very abrupt; the outward or south slopes are also steep. The rivers which pass through the range, such as the Arun, the Adur, the Ouse, and the Cuckmere, have very little fall in the lower portions of their courses, so that the country at the base of the *inner* slopes of the chalk-range, as along the Rother, is but little higher than the tract outside; a very slight depression, such as would submerge the area south of the chalk, would cause the same mass of waters to occupy the transverse valleys and their ramifications beyond.

The tract south of the chalk-range consists of accumulations which have a thickness of from 30 to 35 feet at most; these rest on a surface of chalk or else of nummulitic strata, which have experienced a uniform levelling at some former period, a counterpart of what is being produced at present by sea-action; as around the island of Heligoland,* and other coast-lines. The chalk comes to the surface about South and North Berstead, Shrapley, and Poole Farms at Felpham, and in the parish of Siddlesham.

The higher levels of the chalk-range, which rise to the edge of the escarpment, present a clear surface, free from detritus; remains of lower tertiary deposits are also wanting; in which respects the Downs on the south of the Weald differ from those on the north.

Patches of lower tertiary strata occur between High Down Hill (north of Little Hampton) and the main line of the chalk, as also near Brighton; there is again the well-known outlier of Castle Hill, near Newhaven, where the lower fluvio-marine beds (plastic clay, or Woolwich and Reading Series) are covered, as on the North Downs, with gravel. Further west blue and mottled clays of the same series occur close up to the base of the chalk-hills near Goodwood.

The line of coast from Beachey Head to Folkestone need not now be noticed, as the phænomena connected with it belong to changes, and to a condition of the English Channel of much later date than that indicated by the newer tertiary deposits of Selsea. The manner in which the beds of this series are cut off by the present coast-line suggests that at one time a like condition of surface with that of the Sussex levels extended along the whole range of the chalk, not only as far as Beachey Head, but even across from the Chalk Downs of Sussex to those of the south limit of the Boulonnais, before the subsidence of the land of that interval had taken place.

The rate of removal along the line of the deposits of the Sussex levels is so rapid, as to assure us that the present breadth of that tract is no indication of what its extent has been, even within historical times†, still less of what it was at yet earlier periods.

* Ueber die geognostischen Verhältnisse von Heligoland, t. 2. Von Dr. G. H. Otto Volger.

† See Mantell, Dixon, and the Volumes of the Sussex Archæological Society.

The lower nummulitic strata near the entrance to Pagham Creek present conditions of deposition which deserve notice: between the beds of compact sand are numerous large root-like bodies, which spread over each surface; the beds themselves contain in abundance the casts of bivalve shells, all placed as when living, whilst at intervals are lines of rounded bodies, which consist of clay formed into pebbles, as may be observed now along the margins of lakes, ponds, or estuaries, and which are produced by the ripple of the water where it breaks gently along a marginal line.

Coarse detritus, such as rounded and subangular shingle, is not uncommon in other parts of the lower nummulitic series; it consists wholly of chalk-flints.

French Coast.

Somme.—The land bordering on the east end of the Channel need not be described in any detail, inasmuch as it consists mainly of secondary strata. The littoral deposits of the Somme Department have not been surveyed or described so as to supply us with any very definite details as to the deposits of the low levels, which, from Étaples, occupy a considerable breadth southwards. The valleys of the Canche, the Authie and the Somme, which have their steep sides on the south-west, are all parallel with the axis of Artois, and are probably referable to lines of fracture. The lower portions of these valleys contain subaërial and alluvial accumulations, which include abundantly the remains of large mammalia, associated with land and freshwater shells of existing local species.

At the mouths of the Canche and the Somme there are moreover indications of a small change of level of recent date: this change has somewhat complicated the geological phænomena of these valleys: the sequence on the whole will be found, however, to correspond with the upper part of that on our own Sussex coast.

Seine Inférieure.—Along the rest of the coast of Upper Normandy, the sea now reaches the base of the vertical chalk-cliffs * which are continued with a uniform height as far as Cape Antifer. Perhaps one of the most striking features of the Channel coast is this lofty wall of dazzling white chalk, when seen from a short distance in the offing. The district which extends inland from this part of the coast is overlaid, though not uniformly, by an accumulation of clayey gravel, containing flints much broken, but not worn. I am not aware that any true tertiary strata occur over this surface, at least on the coast-section, till near Tréport; here, and again beyond Dieppe, are the well-known fluvio-marine beds of the nummulitic formation, corresponding with those at Newhaven, but which are here surmounted by a marine deposit of dark sandy clay †. These beds seem to owe their preservation to their having been accumulated in an old depression of the chalk, for the process has been one of filling up—the higher beds overlapping the lower. *The upper surface* here presents just the same uniform level as does the rest of the coast, and the only peculiarity to be noticed with respect to

* Quart. Journ. Geol. Soc. vol. xi. p. 118.

† Prestwich, Quart. Journ. Geol. Soc. vol. xi. p. 230.

the superficial accumulation consists in its very marked horizontal bedding, with layers of drifted sand; I here found pebbles of quartz.

Two sets of gravel-accumulations may be observed here,—one overlying the furrowed surface of that just described; both may be considered distinct, as to age and circumstances of origin, from the clayey angular gravel which covers much of the chalk-area inland.

With reference to our own coast, the gravel-beds of Sainte Marguerite with quartz-pebbles may perhaps be of the same age as those of the high levels near Poole (see p. 45).

The chalk attains its greatest elevation at Fécamp. About ten miles further the strata begin to rise. The lower cretaceous beds there appear on the sea-level, and thence continue to the mouth of the Seine.

The beds subjacent to the chalk are visible for a greater distance along the right bank of the Seine, than they are on the seaboard; they rise in the same direction, or towards Cap la Héve. The rapid reduction in the thickness of the chalk which accompanies this rise of the beds is very remarkable, and with it there is a corresponding increase in the superficial beds of angular flint-gravel.

Wells which have been sunk at Havre show that an old terrestrial surface lies considerably below the water-level in that valley, buried beneath sand and shingle; and like evidences of depression are to be met with along the coast of Calvados.

Whatever may be the age of the accumulations of the platforms of chalk of this part of France, thus much is clear, that they are anterior to the formation of the valleys which have been cut through them*. Thick beds of subaërial detritus are to be found on the sides and the lower slopes of these valleys. Sections of such masses may be seen where the valleys open out on the coast-section; but they do not contain any true gravel-beds, showing the action of moving water, as is the case with so many of the gravel-valleys of this country. Even the great valley which extends from the coast at Dieppe to the denuded district of the Pays de Bray has not the slightest trace of them.

Eure.—Beyond, or south of the Seine, the chalk does not appear in the upper part of the cliffs, but the same rapid diminution in its thickness is continued across the Department. All the circumstances under which this takes place—such as the very irregular surface, produced by lines of deep troughs—agree in a remarkable manner with what may be observed over the Blackdown range of Devon, particularly in the cliff-sections E. and W. of Sidmouth. In the Department of the Eure, as in the west angle of that of the Seine Inférieure, the accumulation of angular flint-gravel which accompanies the reduction of the chalk-strata often exceeds 100 feet in thickness: it is not limited to the chalk, but outspreads it, and covers up the beds of the lower cretaceous series. It diminishes in thickness, however, with its distance from the chalk, so that the oolitic platforms of the Department are mostly free from it. As also in

Calvados,—where the detritus on the surface of the country, between

* Quart. Journ. Geol. Soc. vol. xi. p. 118.

Fig. 1.—*Section of the Coast from Highcliff towards Muddiford* (true scale).

a. Sands. *b.* Line of pebbles. *c.* Barton clay. *d.* High-level gravels. *e.* Old cliff. *f.* Valley-gravels.

Caen and the Orne* consists almost exclusively of waterworn quartzose and old Silurian rocks.

§ II. *Superficial Detritus of the East End of the Channel.*

Dorset.—Detritus caps the summit-levels of all the hills which extend from Devonshire into Dorset; it presents a twofold division†—the lower consisting of more irregular materials than the other, with a marked line of separation, and with this further characteristic for the upper portion, that it contains rounded pebbles of white quartz, porphyry, and granite. It is only in the valleys that those local accumulations are met with which include the remains of the large mammalia. The whole of these high-level gravel-beds were spread out before the surface of these counties was intersected by its present system of deep combes and broad valleys, showing the vast lapse of time which separates these two accumulations.

Passing thence into the tertiary area of Dorset and Hants, we find the vast amount of detritus which covers the surface strongly marked from the coast as far inland as Salisbury. For the purpose of comparing this tertiary area with that beyond it on the west, the geologist cannot do better than follow the coast-sections from Portland and Weymouth Bay, by Studland, and thence to the Solent‡. Poole Harbour is partly due to denudation and partly to depression. On the east is high ground, which at a spot a little to the right of the road leading to Bournemouth will be found to be capped by an isolated mass of gravel, in which are several very extensive pits. This accumulation differs in many respects from the ordinary gravel-beds of the district, the most important point with reference to the present sketch being the presence of waterworn specimens of white quartz, granite, and porphyry. It is very probable that similar gravel-beds may occur over the area which lies between Poole and Dorchester, but whether such is the case or not, I am disposed to consider the high-level gravel east of Poole as an outlying mass of the same age as that which caps all the tabular hills of Devon and Dorset, as far as the valley of the Char; and this, from the presence of these materials alone.

* De Caumont, Topog. de Calvados.

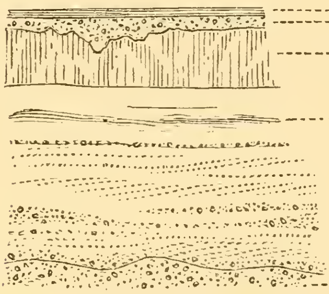
† Trans. Geol. Soc. 2 ser. vol. vi. p. 448.

‡ See Lyell, Trans. Geol. Soc. 2 ser. vol. ii. pl. 30, for a section of part of this line.

Isle of Wight.—The superficial accumulations of the Isle of Wight are remarkably well exhibited in numerous sections along its coast-line, as well as in the interior. From these it will readily be seen that they are referable mainly, first, to an old series which extended uniformly over the whole of the northern or tertiary portion of the island, and, occupying in part the transverse valleys of the central chalk-ridge, was spread out over the whole of the valleys of denudation, nearly to the base of the chalk-range on the south.

These old or high-level gravels are well seen on the hill-tops along the northern coast, and the following section illustrates their general characters.

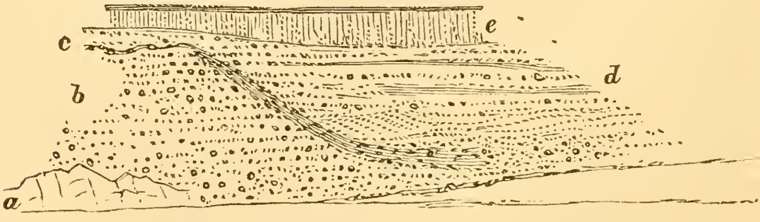
Fig. 2.—*Section of Gravel-beds above Cowes.*



Nearly all the valleys of the tertiary area, as well as of the green-sand, have been cut out since the original outspread of this accumulation. The beds of this age have not been found to contain any animal remains; and, whatever their age may be, this much is certain, that they came next in order of time, after the uppermost fluvio-marine deposits of the Nummulitic formation.

The gravel-beds next in age mostly overlie portions of those just described; but they are superior also to the remains of old terrestrial surfaces. The relations of these two sets of gravel-beds are well shown in the cliff-section at Freshwater Gate, which has been fully described elsewhere*, but of which part is represented in the following woodcut.

Fig. 3.—*Section showing the relations of the Gravel-beds at Freshwater.*



a. Chalk. *b.* Lower or older red gravel. *c.* Old surface and talus. *d.* Gravel with elephant-remains. *e.* Brick-earth.

These overlying gravel-beds, both here and in other parts of the

* Memoirs of the Geological Survey, 1856; Isle of Wight, pp. 3 & 103.

island, have been found to contain the remains of the *Elephas primigenius.*

The changes which are recorded in the section here given, and which may be taken as a type of the relations of two sets of accumulations, both having an extensive range, are as follow:—

1. The older gravel-beds were accumulated, partly in some old valleys (which will be found to be mostly in lines of disturbance) and in part over an extended level surface.

2. The next result indicated is that of excavation, by which the beds along the old valleys were cut out along a central line; the broader expanses were also greatly denuded, and this process in some cases extended deep into the subjacent strata.

3. Terrestrial conditions followed. This was the period of the *Elephas primigenius* and associated fauna; and it was during the long lapse of time which is indicated by the great abundance of these remains, that the older gravel-beds became cemented and charged by peroxide of iron, from the percolation of surface-water.

4. This surface was submerged to as great as, or even to a greater extent than the subsidence that existed during the accumulation of the older gravel-beds: the valleys which had been cut out were again filled with detritus that caught up with it the harder and more persistent portions of those animals which had left their remains there.

These gravel-beds were themselves excavated as we now find them, and nearly along the same lines as before. In these changes each process of accumulation corresponds to a period of gradual depression, and each denudation to a rise.

6. The highest or newest beds, which are referable to a state of things somewhat different from such as exists at present, are those described as the "brick-earth," which is a subaërial accumulation, and therefore necessarily at places cotemporary with fluviatile and lacustrine depositions: such, for instance, in the Isle of Wight, are the beds of sand, clays, and marl which are to be seen in the cliff section of Tolland's Bay*.

Gravel Beds of the Sussex Levels.—No detritus whatever is found along the base of the escarpment of the South Downs, as from Cocking to Duncton, whereas chalk-flints form broad and thick accumulations at the foot of their outer slopes.

The tract beneath the chalk-downs, of which Chichester may be taken as the centre, has been described as a plain, which it is to the eye; but, though the difference of level may be slight, it will readily be seen that it presents two levels; and that, bordering on the chalk, there is an upper zone composed of flint-gravel, as at West Hampnet. In places this gravel has a banded arrangement, from the presence of seams of sand; but where it contains much clay, as is often the case, no such arrangement can be traced. The whole is coloured and often cemented by iron.

Of this age are the gravel-beds of the Broile, thence extending eastwards. They usually overlie lower tertiary clay strata.

* Mem. Geol. Surv. Isle of Wight, pp. 8 & 105.

This upper gravel-terrace has a very marked slope or face along its southern edge.

The second level is that which extends from the base of the upper terrace; it is also composed of gravel, and may be seen in numerous excavations about Chichester, as over the Port-field, and eastwards, along the line of railway. This gravel is much more worn than the other, is cleaner, and has a very marked horizontal arrangement, with seams of diagonally drifted sands. It thickens rapidly from north to south, or seawards.

In places where these latter gravel-beds are worked through, as along or near the line where they meet those first described, the relative positions of the two accumulations may be seen, the lower beds of the red gravel being continued beneath the second or lower-level series. The gravel-beds of the south of Sussex may therefore be divided into two groups, distinguishable by colour, composition, and relative position; the oldest is locally known as the "red gravel," and the newer as the "white gravel."

The beds of red gravel, of which a portion alone now remains, at one time extended over the whole of the chalk and nummulitic platform which supports the deposits of the Sussex levels and patches of it may be seen in advance of the present coast-line as far as low water (see fig. 4, *f*, p. 49). The line of slope which marks their westward boundary is nothing more than the coast-line of the period of the "white gravel" series. The materials of the one have been taken from the other accumulation, and re-arranged.

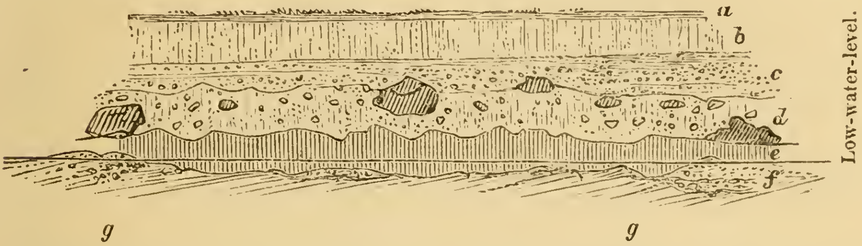
In addition to chalk-flints, the "red gravel" contains blocks of grey-wether-sandstone from the lower tertiary strata; but no animal remains have ever been found; in which respect, notwithstanding its low position, it resembles the gravel-beds of the higher-level gravels on the chalk, and to that series I am disposed to refer it.

§ III. *Deposits of the Sussex Levels, above the Red Gravel.*

1. *Marine Deposits with Lutraria rugosa.*—The oldest of the newer tertiary deposits of the Sussex levels, taking the series in ascending order, is to be seen only at extreme low-water in Bracklesham Bay, thence round or in advance of Selsea Bill, as far as the entrance into Pagham Harbour; it has been met with beneath the overlying deposits of the Selsea peninsula at a depth which places its upper surface below the high-water-level there, and the consequence of this position is, that it is only occasionally and imperfectly exhibited; towards the upper limit of the tide it is generally covered up by sand and shingle; lower down it is presented in detached patches.

This portion of the Sussex series forms the "mud-deposit" of Mr. Dixon's description,—a very fitting name, as, apart from other considerations, its composition distinguishes it from the beds above; it consists of an extremely fine sandy mud, which is so firm and coherent that even small patches resist the action of the sea for a considerable time; but for this, it would be rapidly removed from off the platform of consolidated nummulitic strata on which it rests. (See fig. 4, *g*.)

Fig. 4.—*Diagram-section showing the general relations of the newer Tertiary deposits of the Sussex Levels.*



a. Vegetable mould. *b.* Brick-earth. *c.* Gravel, with occasional seams of sand and pebbles, and with shells. *d.* Yellow clayey gravel, with large blocks. *e.* Marine mud-deposit, with *Lutraria rugosa*, &c. *f.* Lower red gravel. *g.* Older tertiary strata.

The thickness of this deposit, and the probability of its increase seawards, can only be properly estimated when seen at low-water spring-tides ; on one such occasion I measured thicknesses of from 18 to 20 feet at places where the mass was partly above water, and at the same time intersected by deep channels ; in these positions it is seen passing away beneath the sea-bed of this part of the Sussex coast; or, in other words, the area of its accumulation had its main extension in that direction.

From low-water landwards the deposit diminishes in thickness. This is in part due to ordinary coast-line destruction ; but it will be seen that where it passes beneath the higher deposits of the Sussex levels, as in the coast-sections, it has a furrowed uneven surface, showing that it experienced considerable denudation in this direction either before or at the time those newer beds were accumulated. It is not found far inland. It evidently, however, had at one time a greater continuous extension in this direction, from the small patches which occasionally occur.

The dark colour of these beds seems to be partly due to diffused vegetable matter ; their composition, in the uniform minuteness of their particles, indicates tranquil deposition ; the condition of the water beneath which this took place must, however, be mainly derived from the habits of the included *Testacea*.

The whole of this deposit, so far as the limits within which it can be observed extend, is seen to rest on a portion of that broad platform of chalk and nummulitic strata which has been already noticed, with the occasional intervention of patches of gravel (fig. 4, *f*) ; this platform, when denuded, exhibits a surface which is of some interest in the history of the change the area has undergone. On the coast near Medmeney, on the Bracklesham Bay side, the surface is occupied by the remains of a colony of the *Pholas crispata* which has burrowed into it ; and the first peculiarity which strikes the attention is the enormous size which this species here attained. This is not confined to some few cases, which might be exceptional, but every individual has dimensions exceeding the largest known recent examples.

The perforations made by this mollusk are filled with fine sand, such as forms occasionally the lowest portion of the "mud-deposit;" and it is in these cavities, and between the valves of the *Pholades*, that some of the characteristic shells to be noticed have occurred, such as the *Pecten polymorphus*. The largest that I have seen of these *Pholades* measured six inches in length; and it is somewhat strange that so remarkable a form, which has been known to shell-collectors for some time, should not have succeeded in drawing attention to the inquiry as to what species might be associated with it in the same beds.*

The *Pholas crispata* is not only a littoral species, but is one which, from its very restricted range, serves well to determine the level of the tidal waters at the commencement of the Selsea deposits.

Fossils of the Mud-deposit, and its relative age.—The only Mammalian remains which have been found in this old estuarine deposit of Selsea are those of the *Elephas primigenius*; these are tolerably abundant: and there is this point of geological interest attaching to these specimens, that they do not here occur as single and detached teeth, or portions of tusks, as happens in the overlying gravel-beds; but so many parts of the animal have been found together, as to leave no doubt but that entire skeletons lie embedded in this deposit. Such was certainly the case in one instance which came to my knowledge, where the head, with the teeth and tusks, and numerous bones lay together in close juxtaposition.

Gasteropods.

Fusus turricula, Mont. [*Mangelia*] [*Clavatula*, Lam.].
Living, and common on all British Coasts, but essentially a Boreal Atlantic species.
Fossil, in the Red Crag, common; also in the Faluns [*Pleurotoma clavula*, Duj.], where it is scarce. Bridlington.

Buccinum undatum, Lam.
Living in the Northern Atlantic, but does not extend to the Coast of Spain.
Fossil; in the Coralline Crag scarce, in Red Crag common; and extended into the Mediterranean at the time of the Sicilian beds.—*Philippi*; vol. i. p. 226.

Nassa reticulata, Linn.=*Buccinum*.
Living; has a wide range; common on all British Coasts; Mediterranean. A salt-lagoon shell.—*Phil.*
Fossil; Mr. S. Wood states that he has not seen an undoubted specimen of this species from any of the three divisons of the Crag formation. Monog. Crag Moll. p. 33. It is not quoted by Philippi as occurring in the Sicilian beds.

Cypræa europæa, Lam.
Living; common on all British Coasts.

* I have been informed that these *Pholades* were considered by most collectors as recent and not as fossil shells.

Natica monilifera, Lam.

Living, on most of our coasts; ranges as far as North Coast of Spain.

Fossil, in the Red Crag.

Cerithium reticulatum, Da Cost. = *C. lima*, Brug.

Living; British distribution, West and South; it is remarked by Messrs. Forbes and Hanley that this species is "apparently of comparatively recent origin within our area." It ranges along the Coasts of Spain, Portugal, Mediterranean, Africa, Canaries, &c.

Fossil; has not been found in the Crag deposits, but occurs in the marine beds of the Nar Valley (Norfolk), and abundantly in Sicily (*Phil.*).

Scalaria communis, Lam.

Living; British distribution, West and South, to the Mediterranean.

Littorina petræa, Gray, = *L. neritoides*, Linn.

Living; absent or very local on the shores of Kent and Sussex.—Forbes and Hanley, Br. Moll. vol. iii. p. 28. Marks the upper tide-line on most coasts: ranges South to Mediterranean, where it is very scarce (*Phil.*).

Lacuna pallidula, Da Costa.

Common on the British coasts.

Rissoa cimex, Mont. = *R. crenulata*, Mich.

A Southern and Western species; common about the Channel Islands, Spain, Portugal, and Mediterranean.

Has not been noticed in the Crag.

Rissoa reticulata, Mont. = *R. punctura*, Mont.

British distribution, mostly South and West; its wider range has not been ascertained.

Mr. S. Wood identifies this as a Coralline Crag shell. It is not the *R. reticulata* of Philippi.

Rissoa costata, Mont. *R. exigua*, Mich.

Common on the South coast of England, becoming scarcer northwards; both in Irish Channel and German Ocean; most abundant about the Channel Islands; common in Mediterranean.

Not quoted from the Crag; occurs in the marine beds of Sicily and Calabria.

Trochus cinerarius, Linn.

A common marginal shell ranging from high northern latitudes to the North coast of Spain. A Red Crag species.

Chemnitzia elegantissima, Mont.

On most coasts, but most abundant on the South and West coasts of Spain and Portugal, Mediterranean, Canaries.

Scarce in the Coralline Crag; not noticed in the Red Crag.

Bivalves.

Pecten maximus, Linn.

Along the Atlantic shores of the British Islands (Forbes and

Hanley). Ascends the English Channel; ranges along the coasts of Spain and Portugal to the Canaries.

Occurs fossil in the Crag deposits, in the Clyde beds, and in Ireland, Italy, and France.

Pecten varius, Lam.

On all our coasts, and those of France, Spain, Portugal, and Mediterranean.

Is not found in the Crag deposits, and sparingly in Pleistocene beds (Forbes and Hanley); abundant in Italian and Sicilian beds.

Pecten polymorphus, Bronn. See Philippi, Enum. Moll. Sic.

Ranges from Lisbon South; common in the Mediterranean; in Mr. M'Andrew's list of Madeira species.

Fossil in Italian and Sicilian beds.

Note.—This interesting shell was identified by Mr. G. B. Sowerby.

Nucula margaritacea, Lam.: *N. nucleus*, Linn.

Common; with a wide European range; Mediterranean, West Africa.

Scarce in Cor. Crag; common in Red Crag.

Cardium edule, Linn.

Cardium tuberculatum, Lam. [*rusticum*, Linn.] (Forbes and Hanley).

"Essentially a Southern species."—Forbes and Hanley.

Not in the Crag deposits.

Cardium exiguum, Mont.

"More Southern than Northern;" ranges along the Western coasts of the British Islands. In the Mediterranean and Ægean.

Has not been found in the Crag.

Lucina borealis, Linn. = *L. radula*, Lam.

A widely distributed Northern species, but does not apparently range as far South as the coasts of Spain.—M'Andrew. Not noticed by Philippi as living in Mediterranean.

Common in Crag of the Germanic area, and in some marine beds near Valogres. In Italian and Sicilian beds?

Venus verrucosa, Linn.

A South-coast specimen; abundant about the Channel Islands, and occurs as high as Little Hampton. On coasts of Portugal, Mediterranean, and Canaries.

Was not in the German Ocean area at the time of the Crag.

Occurs in the marine beds of Wexford.

Tapes pullastra, Wood.

British Coasts, Channel Islands, and North coast of Spain.

Littoral species, not found in the Crag.

Tapes decussata, Linn.

More common on the South-west portion of our coast than elsewhere; ranges South but not North of the British Islands.—Forbes and Hanley. Common in Mediterranean.

Tapes aurea, Gmelin.

Along the West of the British Islands; in the Channel as high as Little Hampton.

It occurs in some marine beds near Dublin. One specimen only has been seen from the Crag. Mr. G. Sowerby remarks that the fossil specimens from Sussex resemble the Mediterranean variety.

Mactra stultorum, Linn.

Common, with a great range.

In the Crag deposits.

Mactra subtruncata, Da Costa.

A common shell, with a great European range.

In Red Crag.

Lutraria Listeri=*L. piperata*, Gm.

Common in most estuaries and muddy bays.

Lutraria oblonga, Chem.=*L. solenoides*, Lam.

Rare; British distribution, South and West.

Lutraria elliptica ?, Lam.

Lutraria rugosa, Linn.

Encl. Meth. pl. 254. fig. 2. Desh. Tr. Elem. vol. i. pt. 1. p. 274. Living on the coasts of Algeria and Morocco (Desh.); and of the Canaries, South of Spain, and Portugal (M'Andrew).

Fossil in Italy: Desh., Sismonda; but not noticed by Philippi; in Sicily either recent or fossil.

Syndosmya Boysii.

An Atlantic species; rare; ranging to coast of Spain.

In Mr. G. Sowerby's list of Selsea species.

Solen siliqua, Linn.

Common on all muddy shores.

Mya arenaria, Linn.

In bays and estuaries, common; range Northern.

Mya truncata, Linn.

Common in muddy estuaries; range Northern.

Fossil in Crag: Sicilian deposits.

Pholas crispata, Linn.

According to Messrs. Forbes and Hanley "on the southern shores of England, it is reckoned among the less common shells;" it is more abundant to the North.—Brit. Moll. vol. i. pp. 115, 116. It is a Scandinavian species; but is not cited by Mr. M'Andrew from the coast of Spain or Portugal; nor by Philippi as either recent or fossil. The largest known examples exceed 3 in. in length, and are about $1\frac{3}{4}$ in. in breadth; the specimens alluded to are in a subfossil state from some estuary sands near Dublin. It occurs in the Crag, but the examples from that formation are much less than as above.

Pholas dactylus, Linn.

The foregoing list is a limited one, containing only 38 species; it includes some forms not noticed by Mr. Sowerby in Mr. Dixon's work, such as *Cerithium reticulatum*, which is very abundant in this deposit, and it omits several* which I have not seen.

Taking the assemblage as it is here given, and in conjunction with what has been said respecting the deposit itself, we may infer, from the circumstances of position of the *Pholas crispata*, that the relation of the land to sea-level was then, for this spot at least, much what it is now, or that these ledges in which it is found, then lay, between tides, on a coast-line. The *Pecten polymorphus*, which occurs in the sand filling the cavities of the *Pholades* and in other sands immediately above, belongs, when living, to a sea-zone deeper than that occupied by *Pholades*, and ranging from 10 to 12 fathoms; in these sands it is met with only in detached valves, and must have been washed up from a lower to a higher zone.

Subsequently to the condition of coast-line here indicated, some change must have happened which caused the same spot to be included within an area admitting only of the tranquil deposition of mud and silt. Many of the bivalved molluscs of the foregoing list lived in and on this mud, as is evident from the positions in which the shells are now found, more particularly the *Myæ, Lutrariæ*, and *Pullastræ* (*Tapes*); or the whole of this assemblage of shells, as well as the composition of the beds containing them, indicates that this area became an *enclosed salt-water lagoon*, so that the list must be considered as a special one,—the result of local conditions subordinate to, but also clearly indicative of, a much larger marine fauna, which had its full development in some adjacent sea. We may further fairly presume that this fauna, as a whole, differed as much from that of the present Channel waters, as the fossil contents of the Selsea "mud deposit" do from the Mollusca now inhabiting the series of large creeks and lagoons extending from Fareham to Pagham.

It will be seen from the notices appended to the several species, and which have been carefully compiled with reference to their distribution, that the character of the whole assemblage is essentially Southern and Western; that some of the species, for instance, are such as abound on the rocks and in the bays of the Channel Islands, but others hardly reach beyond Torbay on our own coasts. Some which are now found on the Sussex coast do not seem to range further, or into the German Ocean area. This southern relation of the fauna of the lower Selsea deposit is further very strikingly illustrated by the presence of the two very remarkable and abundant forms, *Pecten polymorphus* and *Lutraria rugosa*, neither of which, at present, are to be found ranging further north than Lisbon.

We seem therefore to have indications, 1st, of a warmer condition

* *Pholas candida*, *Lutraria arenaria?*, *Cardium fasciatum*, *Rissoa varia?*, *Trochus cinereus?* [is not this the young of *T. millegranus* or *striatus?*], *Purpura lapillus*, *Helix nemoralis*, *H. hortensis*, *Assiminia Grayana*, *Bulla hydatis*. Great care is necessary in collecting the shells from the lower mud-deposit, particularly on the Bracklesham Bay side, as recent species or such as belong to the present coast, together with shells of the nummulitic series, become imbedded in it on the surface. I entertain some doubt whether *Nassa reticulata* and *Fusus turricula* should have been included. I have no doubt, however, but that the list will ultimately be considered enlarged.

of the waters of the channel, which permitted southern forms to take a more northern range than at present; and 2ndly, of a limitation of these forms to the area of the Channel.

Without entering at present on the question of the relative age of the older beds of the Sussex levels, as compared with the Crag deposits of the Germanic basin, it is clear, even from this short list of species, that the physical conditions which caused this limitation may be carried back in time: the English Channel may not have existed as an internal sea at the time of the accumulation of the Crag series; but, if it did, a natural bar was interposed, and the waters of the two areas did not communicate as they do at present; nor did they communicate with each other until after that climatal change which caused the southern forms to retreat from our shores.

The inference to be derived from the manner in which the Elephants' remains occur in this deposit is an obvious and an interesting one, inasmuch as we thereby arrive at a relative geological date, which is this,—that the lower estuarine beds of Selsea and of the Sussex levels generally were contemporary with what is known as the period of the Large Mammalian fauna. It is, moreover, equivalent as to time with the subaërial accumulations of the chalk-downs, as at Peppering in the Valley of the Arun (beneath which an entire skeleton of an Elephant was found by Mr. Drewett), and of all the peat and freshwater beds of the valleys of the Wealden area, in which the remains of this animal have been met with under like circumstances.

Some terms have of late crept into very general use in descriptive geology, and to which a sufficiently definite meaning has not been attached: thus certain gravel-beds, which in this country have a most extensive range, are commonly designated as "Elephant-gravel," as if the presence of such remains was alone sufficient to mark a geological date. It must be borne in mind that fossil remains are only truly characteristic of any beds when they necessarily belong to the time and conditions under which such beds were formed. Certain assemblages of shells indicate salt, brackish, and freshwater conditions; but, though the remains of terrestrial animals may in some cases be carried out and mixed up with the exuviæ of the marine deposits of their time, such cases must be considered as exceptional. With respect to the gravel-beds in question, the presence of the Elephants' remains is owing to the circumstance that vast numbers of these animals had occupied a given area, and left their remains there anterior to the accumulation of the said gravels. The remains of the *Elephas primigenius* belong to a period of wide-spread terrestrial conditions; the gravel-beds which contain the detached and harder portions of their remains show to how great an extent the area of these terrestrial conditions was submerged.

This consideration equally applies to the case of the Mammalian remains which are found in the Upper Crag of Norfolk and Suffolk.

2. *Yellow Drift Clay.*—The next accumulation which, in parts of the coast-section, overlies the marine deposits with *Lutraria rugosa,*

consists of an exceedingly tough calcareous, and at times sandy, clay (fig. 4, *d*). Chalk in small fragments is abundant in it throughout; it contains also chalk-flints, some of great size, not much fractured, though water-worn. The tenacity of this bed enables it to resist the wash of the sea along the coast-line long after the overlying beds have been removed. As to its mode of accumulation, it may be observed, that it nowhere presents any indications whatever of horizontal arrangement or bedding; but that it is of marine origin is clearly indicated by the shells it contains, such as *Littorinæ* and numerous fragments of *Mytili*: these marginal forms are disseminated irregularly throughout the mass.

This accumulation is well seen between Aldwick and the entrance to Pagham Harbour; it occurs over the whole of the Selsea peninsula, and extends inland beneath the Sussex-levels for a considerable distance: its upper surface is much eroded, and it has apparently been thinned off much in the same way as has been noticed with respect to the "mud-deposit" on which it rests.

Independently of materials from the chalk-formation, there are also occasionally fragments from oolitic strata, and of fossiliferous chert-sandstone from the upper greensand; but the great peculiarity of this part of the series consists in the presence of rocks, which, from their *ages, composition, points of origin, size*, and *condition*, render its mode of accumulation a problem of no slight geological interest. The rocks in question consist of grey porphyritic granites (these are the most abundant), compact red granites, syenite, hornblendic greenstone, mica-schist, green fissile slates, and fibrous chloritic semi-crystalline rocks, masses of quartz from veins, siliceous sandstones, such as those which occur in the palæozoic strata (Lower Silurian) of Normandy, coarse siliceous conglomeratic masses from the same series, micaceous sandstones with *Orthides* (Devonian), and black micaceous shaly sandstones, perhaps from some coal-measure series. With these are blocks of compact limestone, but whether mountain-limestone, or from the older middle palæozoic series of Devon and the Cotentin, is as yet uncertain.

Inasmuch as the upper surface of the yellow-clay deposit has been much abraded, and must by such process have been made to contribute materials to the beds above, some of the series of rocks just enumerated are to be met with there also, as will be presently noticed: their accumulation, however, belongs primarily, and perhaps exclusively, to the period of the deposit now under consideration*. Mr. Dixon notices them in Bracklesham Bay†. Sir R. Murchison met with "a few pebbles of granite" in the lower marine beds between Hove and Brighton ‡.

The *condition* in which the old sedimentary or crystalline rocks occur in the yellow-clay gravel-deposit is either that of perfectly

* Crystalline rocks, in the form of "rounded shingle," were first described by Dr. Mantell beneath the "Combe rock" or "elephant-bed" near Brighton.—Geology of the South-east of England, p. 32.

† Dixon, Foss. Suss. &c. p. 14.

‡ Quart. Journ. Geol. Soc. vol. vii. p. 396.

formed elliptical shingle, or that of large subangular blocks; the rocks of the granitic series are much the most rounded, some presenting beautifully smooth and polished surfaces; the greenstones, though their angles are worn, retain much of the forms resulting from the jointed structure of those masses. On the other hand, many of the blocks are sharp and angular, as is particularly the case with respect to the quartz and slate rocks.

In *size* these older materials range from coarse shingle up to masses of 20 tons weight; the granitic blocks, which are by far the most numerous, are also of larger dimensions than the others. Fragments of greenstone are to be met with from 3 to 4 feet in length. A rounded block of porphyritic granite has recently been exposed near Pagham, by coast-line denudation, at a spot which only a very short time since formed part of a cultivated field; this block measures 27 feet 5 inches in circumference.

It is difficult to define the precise area over which such materials as these, so foreign to the rock-formations of the district, have been distributed, but they will be found wherever the yellow-clay-gravel occurs: they have a wide range beneath the whole of the level extending towards Selsea, locally known as the Man-wood, being met with in the formation of water-courses, and other works. Guided by the coast-section, these materials, either taken numerically or according to their bulk, seem to be most abundant and characteristic in that portion of the accumulation between Bracklesham Bay and Worthing: their apparent increase about the Selsea peninsula may perhaps, however, be owing to the advance which the coast-line there makes.

Rounded blocks of large size also occur as far inland as north of the South Coast Railway, and certainly beyond the limits of the yellow-clay gravel-deposit; they are there covered over by beds of a series which will be presently described. At one time I imagined that the presence of these granitic boulders indicated that the beds in which they occurred belonged to one and the same period, and that the altered character of the beds which contained them was the result of accumulation under shallower water conditions than the yellow-clay gravel-beds: such, however, I have since ascertained is not the case. In many instances where large blocks occur amidst beds which in the coast-sections overlie the yellow-clay-gravels, they have served to protect from denudation small patches, subjacent to them, of the characteristic accumulation in which they were originally deposited: in these positions the larger blocks are outliers, showing the former extent of the yellow-clay gravel-beds; and they may also serve as a measure of the moving power of the water, which when it denuded that area was insufficient to displace the larger masses. The great rounded boulder at Pagham is a good illustration of the relative force of this denudation, which will be further alluded to.

The smaller water-worn specimens of old or of crystalline rocks are of various sizes, such as may be met with on the beaches of the French or English coast of the western extremity of the Channel; and coast-line materials may, we know, be conveyed to great distances. The formation of perfectly rounded shingle, however, as compared with masses of subangular gravel, implies lengthened attrition in places, such as bays, where the materials remain long impounded. If we assume that the rounded granitic and other shingle, now found in the beds of the Sussex-levels, may have followed the coast-line from Cornwall and Devon eastwards, it should happen, that *all* these materials should be water-worn, that similar pebbles should occur along the intermediate space, and that they should increase in bulk and in number westward; but such is not found to be the case.

Again, under the supposition that these materials may have been derived from our own western districts, it is necessary that all the different rocks above enumerated should occur in that quarter. Instead of this, some only of the granites, greenstones, fibrous slates, and limestones are referable to rock-masses occurring between Torbay and the Land's-end. On the other hand, if the fragments contained in the yellow drift-clays of Sussex be compared with a series taken from the rocks composing the Cotentin and the Channel Islands, the agreement will be found very close and striking, so much so, that I was at one time disposed to think that they must have been derived directly from that quarter; and it was very reluctantly, and from the insuperable difficulties which such a supposition involved, that I abandoned it in favour of the view which is here taken.

With respect to the perfectly rounded materials, or shingle, we know that, previous to its removal to where it now occurs, it must have been formed and accumulated on some coast between tide-lines; on one side of the Channel such spot could not be less than seventy miles distant; and although, as has been stated, the materials themselves lead us to look to the French coasts of the Channel, it by no means happens that the whole of the series from which they may have been derived is to be met with at *the coast-line* there. This view involves the supposition of a condition of the Channel-area such as it presents now,—under such conditions no one part of its coast, nor even the whole of the present coast-line taken together could have furnished all the foreign materials now buried beneath the Sussex-levels.

Even were this otherwise, the law regulating the distribution of coast-shingle renders the supposition of derivation from the French coast wholly inadmissible. Shingle can only travel to any distance *in the direction of the coast-line* on which it has been formed. A section across the Channel from the Cotentin to Selsea shows an undulating surface of sea-bed, and deep troughs of 300 feet, across which such materials could not have been so moved.

But, admitting that the smaller shingle from some distant coast might have found its way to our Sussex-levels, by some possible application of the drifting powers of the sea along its marginal line, such powers become wholly insufficient with reference to the more bulky masses which have been here noticed.

The dimensions of the boulder now exposed near Pagham, and the many others of scarcely inferior size which must have been met with, seem to admit but of one supposition with reference to the mode by which they were conveyed,—floating ice is not only a fully adequate, but is perhaps the sole known agent which could have transported these masses; and such I shall now assume it to have been in this case.

Thus much, then, has been established, that at a period indicated by the clay-gravel-beds of the Sussex-levels, marginal shingle and great blocks were drifted away from *some coast-line* composed of crystalline and old palæozoic strata, and which was neither that of the West of England, nor yet of France (Cotentin).

It may, perhaps, be objected to this latter exception, that, if we admit of the supposition of climatal conditions favourable to the formation of coast-ice, materials might have been floated away, not only from the Cotentin and the Channel Islands, but also from much greater distances along the French coasts, as from Brittany; by including which locality, the difficulty as to the points of origin of the various materials at the present sea-level would be partly got rid of.

The seemingly limited area over which the drifted materials are distributed has an immediate bearing on the question as to what was the distance and position of the place whence they were derived. If we suppose that the Channel-area then stood in its present relations to the Atlantic, the nearest points from the Sussex-levels at which coast-ice could pick up the various materials which have to be accounted for, would be from 70 to 150 miles distant: once detached from the coast, the floating masses would become obedient for many days, at the very least, to the combined influence of the wind and tide, before they were stranded, and would hence be distributed indifferently over a very wide area. The juxta-position of the larger drifted blocks seems, therefore, to exclude this supposition, to point at the same time to some nearer source, and to a somewhat different agency of coast-ice.

I have shown elsewhere that the western portion of the English Channel area was occupied during several distinct geological periods by a mass of crystalline and old palæozoic rocks (Journ. Geol. Soc. vol. xii. p. 45); that this mass gave way and subsided from time to time, in a direction from west to east, by which process the present area of depression was gradually formed. It will also be seen that the eastern extension of this mass can be defined for several definite geological periods.

Apart from the older physical arrangements which form the subject of investigation in the memoir here referred to, it must have been felt by most geologists that an eastern extension of the old axis of the Channel-area is necessary to enable us to account for many of the differences which present themselves in connexion with the secondary and tertiary formations of France and England, so that the supposition of a submerged mass of old rocks is by no means a violent hypothesis, contrived to meet a special difficulty.

This is not the place where such views as these can be enlarged upon and illustrated. I may, however, be permitted to state, that we have abundant proof that this old Channel-ridge existed and served to define the form of the area in which the upper fluvio-marine portion of the nummulitic series of the Isle of Wight was deposited,—that it extended to the west and south of it,—and that streams brought down pebbles of its component strata, and deposited them in that basin*. I believe that the older materials found in the upper tertiary deposits of the Sussex-levels were derived from rocks now lying within the limits of the present Channel-area, and that physical arrangements of old date were continued down, with modified prominency, even to the period of the large pachyderm mammals.

To such geologists as may have had opportunities of examining the relations of the oolitic strata to the subjacent palæozoic rocks along the valley of the Dives (Calvados), and have seen the slight distance from the present coast-line at which these old rocks come to the surface, the view here taken may have already suggested itself; but even to such as may not have visited this part of Normandy, the study of a good geological map will be quite sufficient to satisfy them of the very great probability that this relation of the two series may be continued beneath the adjacent sea.

With the waters of the Channel at their present level, the process of coast-line waste will some day reach great masses of old palæozoic slates and sandstones, and project them on the cliff-sections of the French coast. These masses will supply shingle and detritus to the sea-bed then forming, and these will be in part identical with much that is now found in the Sussex deposits: this will happen on a part of the French coast opposite to, or on the meridian of Brighton. Or, if at some past time, not remote, a tract contiguous to a sea-bed so composed has been placed at the sea-level, it must in like manner have caused a similar association of materials in its marginal detritus.

The case here taken, and which thus far is purely hypothetical, becomes extremely probable, if we can show that a portion of the east end of the English Channel area has experienced depression since the period of the large pachyderm fauna.

Starting from the coast-line of France, and applying the same rule as in the case of the Dorset coast (p. 41), namely, that terrestrial surfaces *between* tide-levels do not *prove* change of level, but that, when they pass down beneath low-water, they necessarily do, we have evidences of depression extending along a line 50 miles in extent. The most striking of these are from Benerville to Villers, between the Toucques and the Dives, and again, on a grand scale, east of Vierville, where a wood of trees of large size is seen to pass down beneath the lowest tidal level. In these cases, as in those on our own coasts, the line of depression seems to incline towards the central area of the Channel. Whether this depression was local, such as merely gave greater depth and width to the valley of the Channel, or whether, the whole remaining relatively unchanged, some much larger area was so moved that the Channel-valley was at one time in the condition of dry land, and at another occupied by water, is not a consideration affecting the present question in the least, which resolves itself

* Some beds in the fluvio-marine series of the Isle of Wight are wholly composed of small quartz-pebbles.

simply into this—what was the condition of the English Channel as to its coast-line when certain marginal accumulations were being formed?

If next we examine the bed of the English Channel midway betwixt Calvados and Sussex, we meet with features of outline—such as lines of troughs and an advancing platform, indicative of an old coast-line*: from out of the most northern of these depressions an isolated mass rises nearly to the surface. The bed of the sea in this part of the Channel is remarkably clean, being composed exclusively of subangular shingle. I had opportunities of examining this in 1854, during a calm day, and found the detritus in this portion of the Channel to have been derived partly from old rooks (Silurian of Normandy), and to be mixed with granitic pebbles, and some pebbles of hard apparently oolitic sandstone, together with chalk-flints.

Such a condition of sea-bed at such a depth (45–50 fathoms) indicates subsidence; and if we restore it to such a position relatively with the present water-level as is alone compatible with the accumulation of subangular shingle, the whole of the area to the east, which has an average depth of from 25 to 30 fathoms, would be raised into the condition of dry land. It is on such considerations that I am satisfied that an old coast-line may be drawn across the area of the English Channel which defined its limits in an eastern direction until some time after the accumulation of the yellow boulder-clay of the Sussex levels†.

If this supposition be well founded,—and it has the support of several distinct, but concurrent, sets of considerations,—the next inference to be drawn is this, that, inasmuch as no possible points of origin for all the varied materials to be met with in the Sussex accumulation are to be found around the present coast-line of the Channel, their source must have been along some part of that coast-line which is now submerged: the course of that coast will be in conformity with lines laid down long since, and without reference to the present argument.

Lastly, should a group of old sedimentary and crystalline rocks occur in this interval, it could be easily proved, by reference to their arrangement in the Department of Calvados, or it will be readily seen by reference to a map, that they would agree with, because they would be simply an extension of, the Normannic group.

3. *Marine Gravel above the Drift-clay*.—From Aldwick to the entrance to the Pagham Creek may be taken as the portion of the Sussex coast along which the above-described boulder-formation, as also that which overlies it, may be best seen. Very much, however, depends on the quantity of shingle which may have collected along the upper tide-line.

Wherever the yellow drift-clay (fig. 4, *d*, p. 49) is well exhibited, its surface is invariably furrowed and uneven; on this rests an accumulation of coarse flint-gravel (fig. 4, *c*). At some places this mass has no definite arrangement, but at others it passes into horizontal

* See Map of the English Channel, Pl. XI. Quart. Journ. Geol. Soc. vol. vi.

† See the Map above referred to; and especially the Map, *ib.* Pl. I. vol. xii.

bands of sand and shingle, with sea-shells. One of these, and the principal one, having a continuous range over a very wide area of the Sussex levels, occurs towards the upper part of this accumulation; but there are other seams which are fairly included in it. In these last shells are scarce, and usually much broken; being much in the condition of those to be met with in the upper portions of gravel-beaches; but their variety is by no means so great as the present beach affords.

The upper shell-zone contains abundantly a large form of *Cardium edule*: at one place there was a most wonderful collection in a band of fine sand, but owing to their matrix the shells were in a very friable condition. It could be seen that very many had the valves joined; some few were closed, but mostly gaping; with these was *Turritella terebra*. This condition of the bivalve shells indicates a disturbance of the sea-bed where these animals had lived, and which had transferred them to the higher marginal zone.

The materials of this bed are much water-worn, and consist mostly of chalk-flints. There are also pebbles of granite, porphyry, and other old and crystalline rocks, but which also are much water-worn, and never of large size. It is for this reason, and from the circumstance that the larger blocks of the subjacent drift-formation have never been disturbed by the process of denudation which the latter has experienced, that I am disposed to consider that the foreign materials of this stage have been derived from the waste of the subjacent one, and that the conditions under which the larger blocks have been conveyed to the places where we now find them, had altogether ceased. (See p. 57.)

I believe it to be this stratum which, appearing in many places over the Sussex-levels, and along the courses of some of the rivers (as the Arun), with its characteristic sea-shells, has been taken as an indication of a recent change of level, whereas it is truly anterior to the spread of the brickearth-formation. It is to this level, too, that I think must be referred the old sea-beach from Brighton to Rottingdean. Of this age also are the beds of sand, shingle, and clay described by Sir Roderick Murchison as seen between Brighton and Hove, and of the identity of which with the old beach at Kemp Town he considers there is the clearest proof.

4. *The Brick-earth.*—The uppermost deposit on the coast-section consists of a uniform layer of unstratified clay, with an average thickness of from 2 to 3 feet. (Fig. 4, *b*.) It is of a dark-chocolate colour, contains small sharp splinters of flint, and occasionally a few rounded pebbles, which have apparently been derived from some lower tertiary beds. These materials are dispersed irregularly throughout the mass.

In following this bed from the coast-section inwards, it is seen to form part of that great layer of earthy matter which overlies all the gravel and other beds of the Sussex-levels, and is extensively used for brick-making. The beds fittest for this purpose are those nearest the hills, and where tertiary clay-strata come to the surface; but throughout it is characterized by the small angular fragments of flint, which, when near high ground, are often arranged somewhat in lines. The differences to be observed in the brick-earth of the coast-sections, as compared with that in the pits about West Hampnet and inland, are such as result from the nature of the deposit.

Along the present coast-line the brick-earth contains abundantly and throughout small concretions of iron-ore. There are occasionally also intervals of mud or silt, with a breadth of from 40 to 50 feet, which look much like the old courses of very sluggish waters; but, after very diligent search, I was unable to find any shells, either in the brick-earth or in the silt. The small seeds of some plant are not uncommon.

The brick-earth nearer the hills contains *Helices* and *Succineæ*, as usual. The beds are much thicker, and seams of sand also occur.

It may perhaps appear to some persons in examining the sections on the Sussex coast, that at certain spots the brick-earth passes down into the detrital accumulation next beneath it. Such appearances are very common in beds of all ages. In this case, the two sets of conditions under which the deposits were formed render any such supposition wholly out of the question; and the apparent passage is owing to the circumstance, that the fine sediment of the brick-earth deposit found its way down amongst the coarser gravel as it began to collect over it. In places where the uppermost of the underlying beds consists of fine sea-sand with shells, and only a few pebbles, the line which separates the two accumulations is clearly marked.

With reference to the conditions under which the brick-earth has been formed, it may be stated generally, that it is a subaërial deposit. In every instance, in every country, it partakes of the nature of strata immediately contiguous. Its great thickness in places, as well as the abundance of the remains of certain land-shells now scarce, indicate conditions somewhat different to such as obtain here now. Its most usual character is that of the wash of a terrestrial surface, under a far greater amount of annual rain-fall than we have at present.

5. *Equivalents of the Brick-earth.*—From the subaërial conditions under which the brick-earth was formed, here, as elsewhere, its equivalents will assume every form which materials acted on by meteoric or alluvial action can possibly take; the only characteristic of those accumulations consisting in their larger scale, as compared with similar ones in the present time.

On approaching the chalk-range, the brick-earth passes into a calcareous marl, next into an accumulation of small rounded particles of chalk, and so finally passes into the mass of rubble or talus which is found at the base of the chalk-slopes.

The alluvia of the large rivers, with their more torrential character, which are to be seen in all the valleys which open out from the Wealden area, are also partly referable to the same conditions; for the Wealden district being physically the same then that it is at present, both for extent and elevation, could only have supplied more copious streams under the supposition of a much more abundant rain-fall. Some of these phænomena, however, as regards the

Wealden district, will date back to the time of the large mammalia, as it is beneath the mass of subaërial talus that their remains, as entire skeletons, have been found (see above, p. 55), either beneath the chalk-downs or the sand-hill escarpments.

To this period also must be referred the "combe-rock" of Sussex and the mass of detritus which at Brighton overlies the raised marine beds to be seen in the cliff-sections*, and to which Dr. Mantell, in his excellent description, has given the name of the Elephant-Bed. I would, however, remark, that the remains of the animal in question have been found underneath the talus, as in the deep wells in the town of Brighton, in the foundations for the wall of the Chain Pier Esplanade, and elsewhere in the coast-sections. The remains themselves are mostly more or less water-worn, as if they had been rolled about on the beach on which the talus had fallen.

In any speculations respecting the origin and circumstances of the brickearth-deposit, it must be constantly kept in mind that the present physical features are not those of the period when the brick-earth was deposited.

It is further probable that over the ridges of rocks lying in advance of the Sussex Coast, such as the Barns and Owers, the original land may have been somewhat higher than the level of the plain which now intervenes between the sea and the chalk-range.

The Sangatte beds described by Mr. Prestwich†, and with whom I saw them in 1852, are of the same age with the combe-rock of Sussex, and are accumulated against an old sea-cliff and overlying sea-beds about 10 feet above the present sea-level. The range of this cliff is inland. The marine shingle, which extends so far inland east from Calais, is an indication of a slight rise of recent date. The marls beneath the peat in the direction of St. Omer are the equivalents of the brick-earth.

§ IV. *Indications of recent changes of relative level.*

1. *Solent.*—From Hurst eastwards, as far as the entrance to the Beaulieu river, mud-banks a mile or more in breadth extend along the coast-line. Their upper surfaces are remarkably tabular, and they are only covered at high water. Their mud-banks must have originated under a very different condition of the Solent sea to that of the present time. They have now a steep front along their outer edge seen at low water; it is entirely free from weed, which covers the upper surface; and this is owing to the wasting action of the sea, by which these mud-banks are being cut back along the outer edge; they receive no additions to the surface, and are therefore on the decrease. In this we have an indication of a rise of small amount. East of the mouth of the Beaulieu river there is a broad expanse of shingle, which, near Stone Point, is nearly a fourth of a mile in breadth. The upper surface of this tract is now raised above the highest reach of the Solent sea, as may be seen by following its

* Geol. Sussex, by Dr. Mantell, 1822.

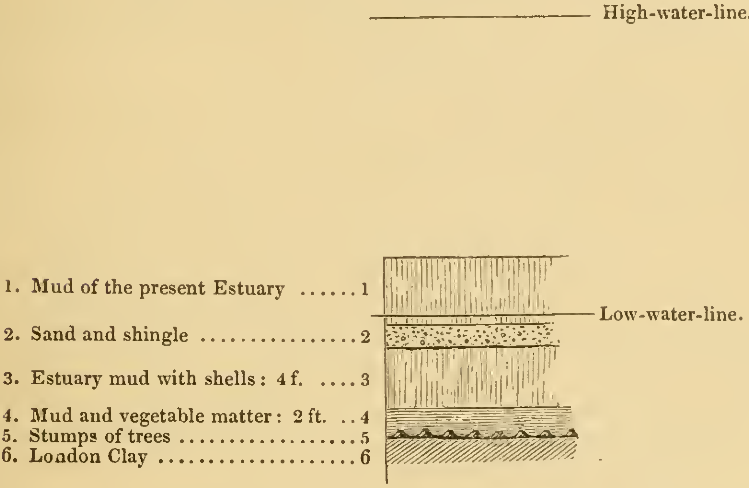
† Quart. Journ. Geol. Soc. vol. vii. p. 274.

outer edge. This state has been a permanent one, as part of this shingle has become overgrown by trees and bushes. On the land-side is a line of vertical cliffs which the sea never now reaches, but which belonged to the period of the accumulation of the shingle at its base, and when the whole was placed at a lower level; so that here again is an indication of a rise.

Like proofs of the elevation of a former line of coast-shingle may be seen on the opposite side of the entrance into the Southampton Water, as in the parish of Alverston round from Gomer to Anglesey.

2. *Portsmouth Harbour.*—In 1847, Capt. (now Col.) H. James, R.E., described a section which was exposed in excavating the new steam-dock in Portsmouth Harbour*. Beneath an upper bed of

Fig. 5.—*Section at Portsmouth Harbour.*



mud (fig. 5, 1), such as now covers the whole of the Portsmouth Harbour area, was a bed of flint-shingle; the level of this was about 2 feet under the lowest ebbs: beneath this was a deposit of blue mud, with the usual estuary shells; and lastly, a band containing much vegetable matter. In this last, the common Grass-wrack (*Zostera marina*) was recognized, together with *Truncatella Montaguei*. There were also the prostrate stems of trees, and stems rooted in the subjacent London clay. The inferences to be drawn from Capt. James's observations are as follow:—

This section shows a former terrestrial surface at 8 feet and more under the level of low-water (from 16½ to 29 feet below high-water), and which passes with a slight dip to a greater depth still beneath the adjacent portion of the harbour. The original terrestrial surface must necessarily have been above the high-water level,—or the vertical depression here indicated must be estimated at from 40 to 50 feet at the very least. The band with *Zostera* and *Truncatellæ* shows that the depression was gradual, and that the Portsmouth Creek at that spot was then more brackish than it is now.

* Quart. Journ. Geol. Soc. vol. iii. p. 249.

An old terrestrial surface of the same age and level as that of Portsmouth Harbour is to be seen at extreme low-water to the east of Southsea Castle, passing beneath the sea. On the land-side it is overlaid by a thick accumulation of mud, sand, and shingle, part of which is now permanently raised above the level of high-water; there has therefore been a rise at this place subsequent to the original depression: the lower mud-deposit of the harbour-section represents a condition of the estuary such as exists at present; and the presence of the intermediate shingle-band is an indication of a greater amount of depression, just as a slight subsidence now would cause the shingle of Stokes Bay to be spread out over the present mud-flats of the harbour.

3. *Isle of Wight.*—At the north-eastern end of the Isle of Wight the latest movement also appears to have been one of depression. There is abundant evidence that rather more than a century ago there existed a line of broad mud-flats in advance of the shore, such as those on either side of Lymington Creek, above described: this fact is noticed by Sir H. Englefield.

When Fielding was at Ryde, on his voyage to Lisbon in 1753, he describes it as totally inaccessible by sea, except at or near high water, as the tide left a vast extent of mud too soft to bear the lightest weight. This mud-bank is now entirely covered by a stratum of fine sand, smooth and firm enough to bear wheel-carriages. This bed of sand now extends from Nettlestone Point, as far as Binstead, having covered two miles of shore during the last half century; and the inhabitants say that it is still extending to the westward.

These sands are many feet in thickness on the east of Ryde, and I ascertained that they everywhere overlie the former mud-bank. The sands are bare at low water, but not to a greater extent than were the former mud-banks: there must therefore have been a subsidence along this part of the coast of very recent date; and, if we may judge from the increasing thickness of the sands from west to east, the depression has been greatest in that direction.

An attempt was made some time since to reclaim Brading Harbour, an area of considerable extent at the eastern end of the Isle of Wight, and much of which is left dry at low water. The sea was shut out, and in the course of the works for the drainage of the tract, there was discovered an old well, lined with stone and filled with estuary-mud, at a spot which previously had been, and now is, permanently submerged. In this case a movement of subsidence seems to have taken place within a very recent period.

It would then seem, that, taking the central line of the valley of the Medina, there have been depressions on either side, east and west (Newton River and Ryde). Beyond the Yarmouth valley the late Prof. Edward Forbes noticed some evidences of recent elevation.

On the extreme south of the Isle of Wight there is evidence of like unequal movements, which seems unexceptionable. There are three headlands here lying east of one another; of these, St. Catherine's Down, 850 feet, is on the west, distant about three miles from Week Down; and at about one and a half further east, Shanklin Down or

Dunnose, 792 feet. "Concerning these downs, a singular circumstance is remarked by the inhabitants of Chale. Dunnose is now about 100 feet above the line of Week Down, "yet old persons affirm that within their remembrance Shanklin Down was barely visible from St. Catherine's;" and that "old men have told them they knew the time when Shanklin Down could not be seen from Chale Down, but only from the top of the beacon*."

I examined carefully the whole of the low tract which extends from the sluice at the upper end of Brading Harbour, in order to ascertain whether this evidence of depression was confirmed. This tract is now so low that a depression of a few feet would insulate the whole parish of Yaverland; as it is, the sea is excluded on the side of Sandown Bay by groins, which serve to collect a great shingle-bank. The sluice at Brading, by which the water of the Yar escapes, shows a fall of about 8 feet, which will give 10 feet at most for the elevation of Sandham Levels above low-water. Had there ever been a greater amount of depression at this place, deposits like those of Brading Harbour would be found over it; that such do not occur is evident from the materials thrown out in forming the deep water-courses. On the other hand, the roots of trees are not uncommon, as if it had at some time been a wooded tract. It would therefore seem that the Sandham Levels now occupy a lower level, with reference to present sea, than they have ever done before.

4. *Pagham Harbour and its neighbourhood.*—In Bracklesham Bay, and off the entrance into Pagham Harbour, at extreme low-water, estuarine deposits, with shells in their positions of life, are to be seen. Taken by themselves, these beds would not indicate change, inasmuch as they might possibly be the remains of certain depressed or estuarine areas at a time before the coast had been cut back to its present outline. Within the area of Pagham Harbour, however, there are sections which show a change like that to be observed at Portsmouth (p. 65). A silt-deposit, with bands of *Cardium edule*, *Scrobicularia piperata*, and *Mactra solida*, overlies an old terrestrial surface with trees, which are rooted in the uppermost of a series of beds which must have been part of a marginal sea-zone. According to this section (fig. 6, p. 68) there have been, first, a movement of elevation of beds into subaërial conditions, then a long period of terrestrial surface, and finally a subsidence, followed by the accumulation of estuarine mud (fig. 6, 1), which corresponds with the lower deposit (fig. 5, 4) in the Portsmouth section.

At Felpham, east of Bognor, the order is precisely the same†. The old terrestrial surface at these places indicates depression; but the overlying deposits show that the area in which they were formed was permanently submerged, whereas it is only very partially so at present; there has therefore been a movement of elevation.

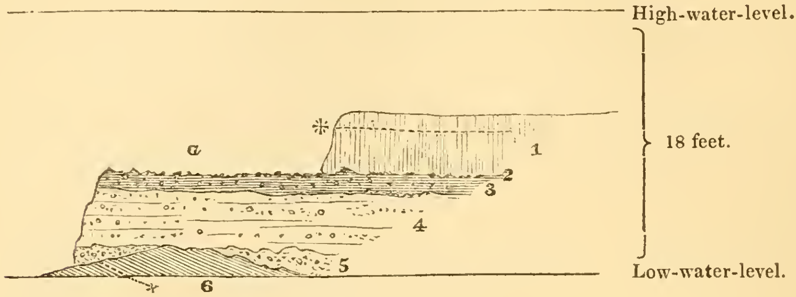
In the fourteenth century mention is made of a sudden irruption of the sea on the Selsea coast, and the consequent loss of 2700 acres; that this was brought about by subsidence, and not by the gradual

* Worsley (1781), quoted by Englefield, Isle of Wight, &c., p. 44.

† See Dixon, Foss. Geol. Suss. p. 31.

encroachment of the sea, is evident from the incidental notice of Camden. "In this isle remaineth the dead carcase only as it were

Fig. 6.—*Section at Pagham Creek.*



1. Estuary-mud, with a strong band of shells(*).
2. Stools of trees with their roots *in situ*; *a.* Platform with roots and trees.
3. Ochreous and blue mud, with shingle and shells.
4. Gravel and sand with marine shells.
5. Ferruginous gravel.
6. Lower Tertiary sands and clays, with a band of mud-pebbles at +.

of that ancient little city (Selsey), hidden quite with water at every tide, but at low water evident and plainly to be seen."

The only place at which a good section of the estuary-beds of South Sussex is to be seen is at low water on the east of Pagham Creek, and is as follows (see fig. 6):—(No. 1) a deposit of estuary-mud, which thins away east and west, resting on muddy shingle and subangular gravel (No. 3), which, though of small thickness, is divided into two bands, the upper being bright-yellow, the lower blue; together they are not more than a foot in thickness, and it is difficult to say whether the trees (No. 2), the stems of which are seen surrounded by the gravel, grew where the gravel-bed formed the highest stratum, or whether it has been accumulated round them; that they were rooted in the subjacent clayey gravel is shown over a large extent of denuded surface (fig. 6, *a*) at this place.

Beneath No. 3 is a deposit of clayey and sandy shingle, containing sea-shells and from 3 to 4 feet thick (No. 4); No. 5 indicates patches of the old glacial gravel, resting on older tertiary sands and clays.

The whole of this section is about midway between extreme tide-levels, so that there must have been several oscillations of level here *subsequently* to the brickearth-deposit.

1st. The main beds (No. 4) must have been raised into a sub-aërial surface, which (2ndly) must have been depressed to receive the covering of estuary-silt (No. 1).

It would thus seem, that, whilst the coast-line of Hants and Sussex has been undergoing the process of recent elevation, the opposite one of the Isle of Wight has experienced depression. And also that the estuary deposits from Portsmouth eastwards, as far as Lewes, show a like series of oscillations throughout.

There is a great deal of authentic evidence as to the extensive waste which the land of this part of the coast has experienced within the historical period; and, when to this are added the effects produced during that long period antecedent to such records, it is not too much to speculate on a time when a low level plain extended over the rocky ledges of the Middleton, Bognor, and Barn rocks, and from Selsea so as to include the Owers. (See p. 64.)

§ V. *Summary.*

It was only a very short time since, and that, too, in the most advanced treatises on systematic geology, that certain superficial accumulations of every European district were grouped together, as belonging to "the diluvial period." Recent investigations are now beginning to assure us of the great amount of physical change which is referable to that period, and also that it was not transitory, nor convulsive, as it has been frequently represented. Already it is separable into stages and subdivisions, whereby the lapse of time is becoming clearly marked out.

The knowledge we possess of the history of these later changes is as yet a very imperfect one, and it is not perhaps too much to assert, that, of all geological periods, that which comes nearest to our own times is the one which is the *least* understood. If the accumulations themselves in these regions are wanting in those vertical dimensions which speak directly to the eye as to the vast duration of the older palæozoic, secondary, and tertiary periods, the very fact of great physical changes having taken place during comparatively much shorter periods of time is in itself a consideration which renders the earth's recent history even more strange than its remoter one.

The amount of change which took place in the relative distribution of land and water over the whole northern hemisphere of the globe during this same "Diluvial period" will be found to be as great, if estimated according to area, as that indicated at any earlier times; whilst it presents moreover such a wonderful uniformity in the direction in which the change took place, that, when fully worked out in all its details, it may perhaps enable us to arrive at a cosmical law for the *cause* of such changes on the earth's surface.

In the introductory observations on the land bordering on the English Channel, the superficial accumulations were particularly alluded to, in order to point out, that even in places where these had all been considered as of one age, yet two or more intervals, marked by great changes in the configuration of the surface, were clearly indicated. The interest which attaches to the deposits of the Sussex levels consists in this, that through them several more terms are intercalated in the series of superficial accumulations, and are there characterized by forms of life, whereby the conditions of the stages are clearly marked. This circumstance is owing to the very remarkable fact, that a portion of the Sussex coast has been placed at several periods, dating back to the oldest tertiary times, in precisely the same position with respect to the sea-level.

The high-level gravel-beds, which in their extension from the south-east into the western districts of this country pass over the edge of all the lower tertiary strata, must be obviously referable to some period intermediate between the upper fluvio-marine series of the Isle of Wight and the Crag: such may also be the case as to the gravel-beds next in succession, in respect of age; but with reference to the question as to what were the conditions under which this wonderful outspread of detritus took place, and what were its equivalents elsewhere, we know nothing whatever; we have not even any certain indication as to whether the mass of water by which it was effected was salt or fresh. The vast accumulations of angular chalk-flints which progressively thicken as the chalk is reduced, both in Devon and in the Department of the Eure, as if they had been dissolved out, but not moved, are inexplicable by any agencies with which we are as yet familiar.

The British area had however become, at least in part, a terrestrial one at the period of the fauna marked by the *Rhinoceros Schleiermacheri* and the *Mastodon angustidens*, anterior to the accumulation of those marine deposits of the Germanic area which are known as the Crag. This terrestrial fauna occupies a distinct place over a large European area.

The next group of terrestrial forms is that of the *Elephas primigenius*, *Rhinoceros tichorhinus*, &c. with which, as we have seen, the marine deposits of Selsea were contemporary: and, according to the present state of our knowledge, these two assemblages of terrestrial animals differed more from one another than the existing mammalian fauna of our area does from that of the *Elephas primigenius*.

The next question which arises relates to the condition of the English Channel area at the period of the Crag-deposits of the German Ocean. As far back as the year 1825, M. Desnoyers gave an account of certain tertiary strata which occur in parts of the Cotentin; and, referring more particularly to the beds which are found at Santenay and at Auxais, he then stated that he considered them as "analogue aux terrains du basin de la Loire." Sir Charles Lyell, in 1841, after an examination of the several localities described by M. Desnoyers, and a comparison of the fossil shells with those of the Crag and Faluns deposits, suggested that the beds of the Cotentin belonged to the Crag, and were the equivalents of the Faluns, and that all were referable to his miocene period.* The beds in the neighbourhood of Carentan, by the presence of *Terebratula grandis*, suggest comparisons with the Crag. With this exception, there are no deposits on any part of the western shores of the Channel, none certainly on our coasts, which can be compared with that formation. All the raised marine beds on our western coasts are clearly referable to a period during which the marine fauna was excessively poor; and, with the exception of *Terebratula grandis*, the other shells of the Carentan deposits, such as *Lucina borealis* and *Pecten pusio*, are such Atlantic shells as are now found abundantly about the Channel Islands.

* Subsequently Mr. Wood and Sir C. Lyell have referred the Crag to the pliocene period.

On the whole, I am disposed to consider that the fossiliferous deposits of Carentan more nearly correspond with those of Selsea than they do with the Crag, and that the English Channel area was mostly in the condition of dry land at the time that the area of the German Ocean was occupied by the Crag-sea.

The peculiar molluscan forms of the Selsea deposits point to a limitation of a marine province in that direction, whilst their habits indicate at the same time shallow water and marginal conditions; circumstances which concur in showing that for that period the eastern extension of the channel may be represented by a line extending from the coast of Sussex to that of Lower Normandy*, and that the remaining portion, or what is now the eastern end of the English Channel, was in the condition of dry land.

The connexion of our area with that of the Continent was dependent on the continuity of those lines which connect our Wealden-area with that of the Boulonnais.

The temperature of the waters of the English Channel during the period of the *Elephas primigenius* and its associates was such as may now be met with twelve degrees further south.

To this period there succeeded one of a much lower sea-temperature; and this is indicated alike by a comparatively poor molluscous fauna, and by the results of the formation of coast-ice; but the condition of the Channel-area, as to extent, must have been much the same as during the former period,—provided the speculations as to the source of the foreign materials found in the Sussex-levels be correct (see p. 61).

The old rock-masses which entered into the composition of that former coast-line, and which are now traceable in 45 fathoms water, imply that the depression producing the present central line of the channel had at that time only extended thus far east.

The first stage in this process of depression is that which is indicated by the marine gravel-beds which overlie the accumulation with the drifted boulders, and in which, as we have seen, we have indications of only ordinary moving powers along the coast-line, and a return of an assemblage of mollusca, without the peculiar forms of the subjacent deposits, but very like such as we have now.

This stage shows also that the sea then had a greater extension than during the deposition of the boulder-group, as the gravels overlie and overlap it; or, in other words, the eastern end of the channel was depressed, so that its marginal line reached portions of the chalk-ridge, as from near Brighton eastwards.

The climatal conditions indicated by the brickearth-deposit are excessive rain-fall and great moisture of the surface. The first of these may be implied by the vast thickness to which these subaërial beds sometimes attain, and the distances to which they have been spread out; the second is shown by the very general diffusion of *Succinea oblonga*.

If the suppositions as to the equivalents of the brick-earth be correct, then the depression of the remaining portion of the English

* See Map, Pl. I. Quart. Journ. Geol. Soc. vol. xii.

Channel to such limits as it has now, and the final opening of a communication with the North Sea, must have taken place subsequently to this same brickearth-period.

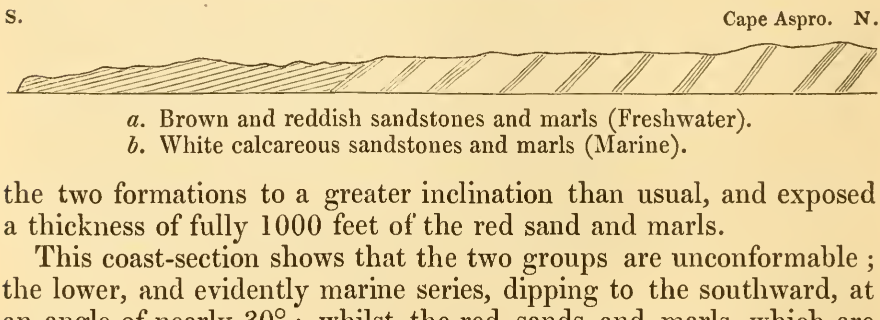
On the Geology *of* Varna, *and the Neighbouring parts of* Bulgaria. By T. Spratt, Capt. R.N., F.R.S., F.G.S.

[Read June 18, 1856.]

Varna and the Coasts to the South.—The Varna district seems to consist generally of two distinct formations: viz. 1st, a series of yellowish and grey deposits, composed of calcareous sandstone and sandy marls, with sometimes an oolitic bed interstratified; 2ndly, a series of arenaceous marls, sands, and fine gravel, of a reddish-brown and greyish colour, which overlie the former, and occupy the tops of the ridges, or occur on the sides of some of the valleys.

The lower group is marine and appears to be of the Eocene Tertiary age; it attains a thickness of fully 1000 feet in some localities. The overlying red sands and marls are seldom found in greater thickness than from 100 to 200 feet in the immediate vicinity of Varna; having been no doubt much denuded from that district. On the coast, however, at Cape Aspro, about fifteen miles south of Varna, and ten miles north of Cape Emeneh, the termination of the Balkan, the cliffs show a section of the two series of deposits together, as seen in the following sketch (fig. 1). A local disturbance has here tilted

Fig. 1.—*Section at Cape Aspro.*



a. Brown and reddish sandstones and marls (Freshwater).
b. White calcareous sandstones and marls (Marine).

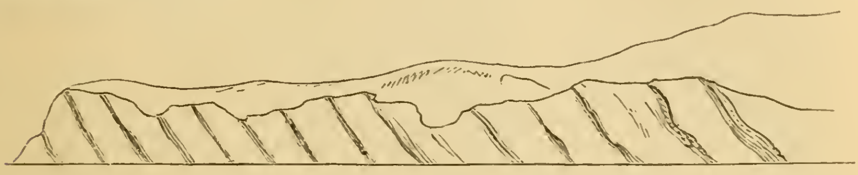
the two formations to a greater inclination than usual, and exposed a thickness of fully 1000 feet of the red sand and marls.

This coast-section shows that the two groups are unconformable; the lower, and evidently marine series, dipping to the southward, at an angle of nearly 30°; whilst the red sands and marls, which are probably partially, if not wholly, of freshwater origin, overlie them at an angle of about 20°.

Cape Aspro is so called from the whitish colour of the cliffs that commence at this cape and extend northward along the whole coast to Cape Kaliakrâ and Cape Shablur, and present everywhere the yellowish white marls and calcareous strata; varying, however, in some few localities, by the more marly and less calcareous nature of some of the beds; but all lying nearly horizontal.

To the southward of Cape Aspro, the disturbances in the deposits increase with the increasing elevation of the ridges, as they approach the Balkan: and the sections exhibit occasionally some of the shales and schistose rocks of an older formation; until at Cape Emeneh, the termination of the Balkan range, we have these strata appearing almost vertical, under the monastery that stands upon the Cape. The strata dip here to the northward, as seen in the accompanying sketch (fig. 2), taken from the sea while passing.

Fig. 2.—*Section at Cape Emeneh.*



Some two or three valleys were briefly examined by me on the south side of the Cape towards Monembasia; but I could find no fossils in the shales at either of them. In mineral character they greatly resemble the shales of the Bosphorus.

The shores of the Gulf of Bourgas, from Monembasia to Bourgas, are lined with low flat hills, composed of red unfossiliferous marls, from 40 to 60 feet in thickness, and apparently of recent and perhaps volcanic origin, since on the south shore of the gulf there are evident volcanic productions, which appear to be partially of a late geological age.

The Island of Anastasia (or Papas, as it is sometimes called, from the monastery upon it) is composed of an indurated volcanic mud, which contains quartz-crystals, like a porphyry. It is of a reddish or rusty-grey colour, and is stratified; but with irregular strata. The points and the coast adjacent to the island, and to the westward, are composed of yellowish and brown marly sand, about 30 feet in thickness, overlying reddish volcanic rocks, similar to those of Anastasia; with conglomerates of serpentine and other igneous productions. The reddish marls overlying the latter seem to have been derived from the waste of the volcanic rocks; and to have been deposited in quiet but muddy waters.

The point to the east of St. Anastasia, towards Liziopoli, as well as the hills south of it, are composed entirely of granite, and probably are of much older origin than the serpentine-conglomerates and the indurated and contorted strata of the Island of Anastasia.

Varna Bay and the Lakes at Allahdyn.—Returning to the neighbourhood of Varna,—the cliffs are composed of the yellow and white calcareous strata and sandy marls, here containing abundant fossils; chiefly the casts of marine shells, both univalves and bivalves; but the specimens are too fragile to be preserved. There are, however, Oysters and Pectens perfect. I could find no Nummulitoid shells in the deposits immediately around Varna; but at the upper part of the lake near Allahdyn, where the formation seems to be the same in general mineralogical age, character and size, *Nummulites* are most abundant; particularly in the cliff close to the watering-place of the Light Division, when encamped there. Over Kepedjeh also, on the south side of the river connecting the two lakes, the *Nummulites* were equally abundant.

At both these localities the formations consisted of a series of calcareous sandstones, of very fine grain, which pass sometimes into a compact limestone, several feet in thickness: but this is partial; in general the more durable stone is confined to the uppermost strata in this neighbourhood, and attains a thickness of 20 and 30 feet; beneath which are white arenaceous marls and sandstones with oolite, which together are fully 1000 feet thick near Devno.

The upper and more indurated stratum is here composed of a mass of organic remains, chiefly *Nummulites*, *Operculinæ*, and *Orbitoides*, in all ages of growth; with *Pecten*, *Terebratula*, and an *Ostrea* with a very thick shell; as seen in the specimens forwarded *.

Columnar condition of the Nummulitic Rocks at Allahdyn.—Connected with the highly fossiliferous condition of the upper existing stratum of this deposit, a curious feature has resulted from the manner in which the rock in some places has apparently become weather-worn into vertical pillars.

A large group of these columnar masses exists about a mile and a half north of the ground occupied by the Light Division and close to the upper Shumla road, see fig. 3. When I visited the camp, they were generally believed to be artificial, such as relics of a rude temple of some early people. Certainly a passing glance might easily lead to the idea of their having been formed by man for some such purpose. But a close investigation, showing their irregularity in position, shape, and height, clearly indicates that they are not artificial, as Col. Hamilton, of the Grenadier Guards, has already stated †. For there are some partially formed in some of the rocks in the vicinity, as seen in a pair that are nearly formed out of a detached mass of rock over the village of Kepedjeh on the south side of the plain dividing the two lakes. In this instance the accidental hardness of the upper portions has hitherto retained the two columns united. The resemblance of this mass of rock to a Cromlek or a Druidical altar, together with the rude columnar masses scattered over the country near, is naturally suggestive of their having some connexion with the earlier worship of the East. They may indeed have been so used, from their adaptation to the religious ideas and worship of an earlier people; but certainly they were not the erection or the work of man. They are, in my opinion, natural productions, and having, as such, a geological interest, I am induced to give two sketches ‡ of the group near Allahdyn and to dwell more upon them.

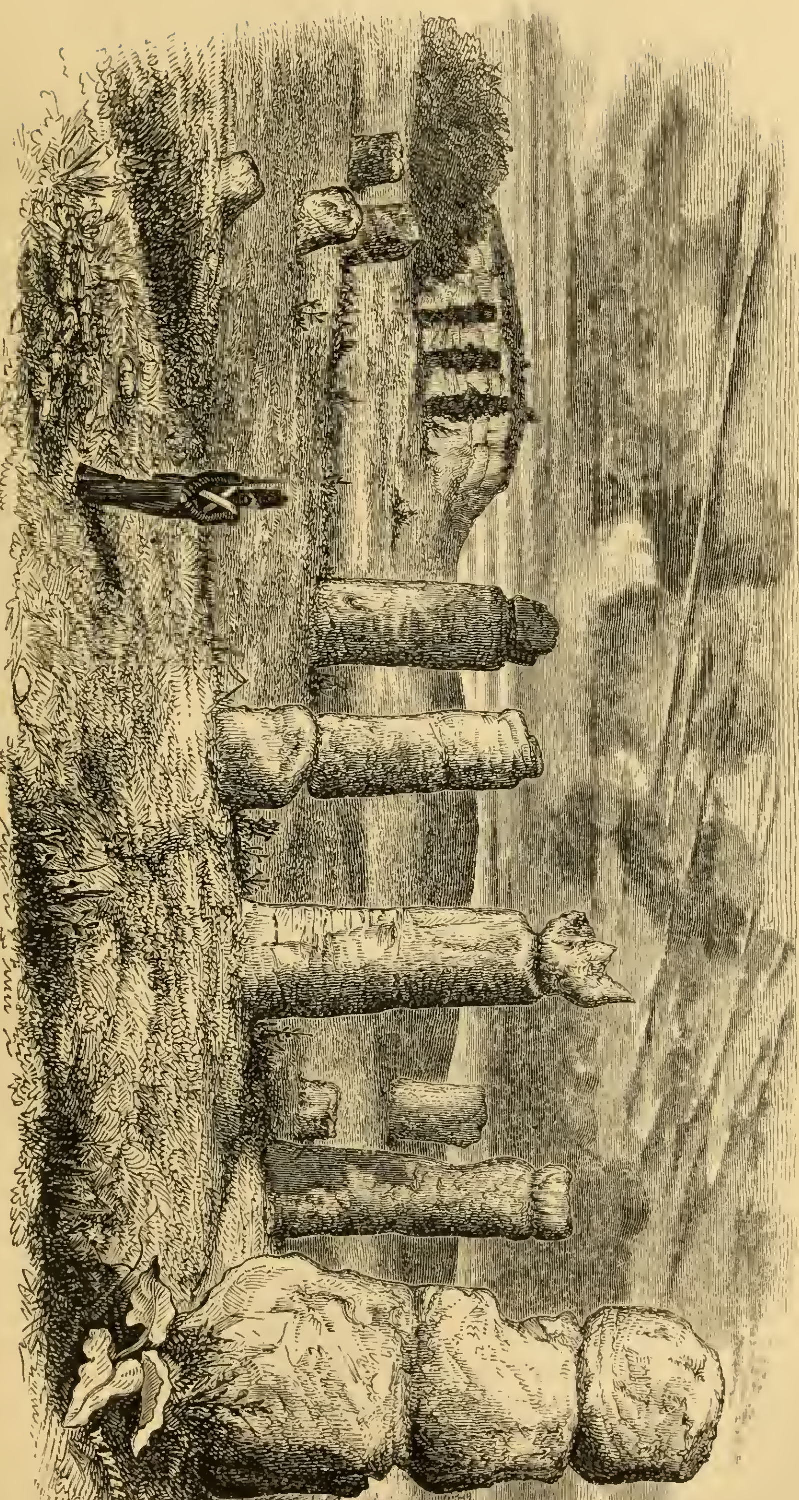
* For a list of the fossils accompanying this communication, see Appendix, p. 82.

† Quart. Journ. Geol. Soc. vol. xi. p. 10.

‡ Fig. 3 is a reduction from the author's original sketch of the northern half of the group of columns at Allahdyn; with the exception of the characteristic column on the right-hand foreground of the engraving, which has been transferred from the author's sketch of the southern portion of the group.

Fig. 3.

Columnar Rocks near Allahdyn, Varna, in Bulgaria.



In the left-hand distance the face of a rock is seen to be weathering into a columnar state, by the formation of a cavern with pillars left standing at the entrance.

The surface of the rock in the vicinity of these columnar masses is, I observed, sometimes much split into vertical cracks, causing the portions denuded of soil to bear some resemblance to an open pavement of flat slabs.

The atmosphere and rain, probably, operating together in those rents early exposed, wearing down the sides and angles, and increasing the openings, have finally left the hardest portions standing as isolated columnar masses, or reduced to detached spherical nodules. The contained fossils have, from their greater hardness, resisted the degradation, which probably was more chemical than mechanical; and the *Nummulites*, so abundant in the stratum from whence the columnar masses were derived, having thus become detached, may be gathered in great quantities at their bases. At the small group of columns over Kepedjeh, this nummulitic sand is so thickly strewed, together with rounded nodules of the limestone, as to resemble the dry bed of a river, although situated upon the slope and top of the ridge.

Similar conditions exist in every group of the columnar rocks that I saw in the neighbourhood: they are derived, as I before noticed, from the uppermost remaining deposit of the Lower Marine Tertiaries at this locality, which is, in the vicinity, immediately overlaid by the reddish-brown sandy marls of the second series of deposits which I have noticed.

The rounded and apparently water-worn character of these columnar masses and nodules, and their existence on the surface of the Marine Tertiaries, are suggestive of their having originated at so early a period as the time intermediate between the two groups of deposits, and during some *moving* condition of the covering waters at that period. I am not prepared to deny this; for it seems very probable; although my impressions on the spot were always favourable for an origin, degradation, and waste at a recent period, and in fact now in process, under the atmospheric influence.

But in support of their older origin, I am induced to mention a curious fact, that seems to support this idea; viz. the apparent existence of a corresponding group of columnar rocks in the Bay of Varna, which rise up in pinnacles from 5 to 8 and 9 feet above the bottom. They were not discovered in sounding the bay until it became crowded with our transports upon the preparation for the Crimean expedition. No one at the locality was aware of their existence, until the hawsers of an English transport and the chain-cable of a French brig, anchored near the spot, were found entangled at the bottom amongst what the French captain expressively called "A group of columns;" for the lead would not remain upon their summits, but fall, as I myself proved, from 3½ fathoms into 5 fathoms, the average depth around them. A diver sent down by me confirmed the fact of their being elevated pinnacles of rock; and not a wreck, as might be imagined.

This fact seems to suggest the occurrence of a group of columns in the bay corresponding to those at Allahdyn: and thus, if the former be identical in respect to the deposit with the latter (for they must have been also covered subsequently by the group of red marls, &c., and entirely denuded again), we have the fact or idea of the Devno Valley and Varna Bay having been formed by a depression of comparatively recent date.

North of Varna.—I shall now make a few remarks upon the deposits lying north of Varna, towards the Danube and the Dobrudcha. A line of steep banks or cliffs extends from Varna to Cape Kaliakrâ, which are everywhere formed of the yellowish limestone and sandy marls, with a thickness of from 400 to 500 feet; and this group extends to near Mangalia, where the overlying reddish sands and marls take their place, and form generally the Steppe-country of the Dobrudcha. The ridges or plateaux of the latter district attain generally an elevation of between 200 and 300 feet, as in the direct line across from Kustenjeh to the Danube. On this line, rocks of the older Tertiary period are exposed at the base of the reddish marls and sands, on the edge of the lower Korason Lake, but are not seen on the Black Sea shore of the Dobrudcha. At Baljik the edge of the steppe is nearly 600 feet above the sea.

These deposits are generally less indurated than at Varna, and are, for the most part, more marly, passing, in some strata, into an indurated calcareous marl. The upper portion, for nearly 100 feet, is a white and grey marl, of fresh-water origin, and apparently conformable with, or passing gradually into, the marine deposits below; both being nearly horizontal. The freshwater deposits appear to have resulted from the waste of some of the former, although somewhat more sandy. Land-shells are also found in some of the overlying beds of white arenaceous marls above the purely freshwater deposits. The whole are here capped by a few feet of a red earthy marl, that seems to belong to the second group of deposits, usually red or brown; and to connect those below, of freshwater origin, with them also.

[In a letter * received since this paper was read, Capt. Spratt says—

Having touched at Baljik for two or three hours in August last, I had an opportunity of making additions to my former account of its formations. I found the general distribution of the strata to be as follows:—

At the base are 150 or 180 feet of dark-grey and brownish marls, thinly laminated, and containing numerous marine fossils, generally very minute †. These marls form apparently an upper member of the Varna series. They lie nearly horizontal, and are overlaid by about 200 feet of a white thick-bedded marl, containing only casts of a small striated bivalve, like a *Cardium*, especially like the one in the freshwater deposits of the Dardanelles.

This mass of white chalky-looking marl seems to be unconformable to the lower marine bed, although nearly horizontal also. I think that probably it is of brackish-water origin: it passes upwards into a series of white and greyish marls, indurated occasionally in

* Read at the Evening Meeting, December 3, 1856.

† A small packet of this shelly deposit has been brought to England by a friend of Capt. Spratt. The shells are small, and prove to be *Trochus*, *Buccinum*, *Bulla*,

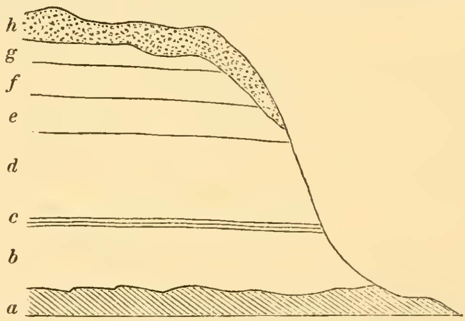
thin strata, which are replete with freshwater shells, associated sometimes with the above-mentioned *Cardium*.

These are also from 150 to 200 feet in thickness, and the fossils belong to the genera *Planorbis*, *Limnæa*, *Paludina*, *Cyrena*, and *Cyclas*?, with abundant specimens of *Helix* in the upper 40 or 50 feet of the series. The whole is capped by a fragment of reddish earthy marl, only a few feet thick.

Capt. Spratt also remarks,—

I have satisfaction in stating that my idea of the reddish and grey sands and marls of the Dobrudcha (Kustenjeh, &c.) being of freshwater instead of marine origin or "drift" was made somewhat more evident by a recent examination and visit to Kustenjeh, where I found the lower bed of grey marl or clay to contain a fragment of an Ele-

Fig. 4.—*Section of the Strata at Kustenjeh, Black Sea.*



a.—4 to 6 feet of oolitic yellowish-white limestone with fossils, probably a member of the nummulitic series, and very like the Varna and Sebastopol rocks. (This was not seen by me in 1853.) It dips 8° or 10° to the N.E.
b.—12 to 15 feet of unconformable greyish marl or clay, with an Elephant's tusk.
c.—Gypseous bands with casts of *Cyclas* or *Cyrena*.
d.—25 to 30 feet of reddish marl, with nodules of gypseous crystals, but no fossils. It passes into
e.—About 12 feet of reddish-black earthy clay, which is without apparent stratification, except of colour, and passes into
f and *g.*—Reddish-grey and whitish-grey sandy marl, from 20 to 30 feet thick, very like the alluvial mud formed by the Danube, and without fossils.
h.—Superficial soil with pottery.

This section gives a good idea of the soft superficial deposits extending through the Dobrudcha.

Rissoa, *Cardium*, &c. There are also numerous *Foraminifera*, of which the following is the list:—

Lagena.
Entosalenia.
Rosalina Beccarii.
Nonionina granosa.
Polystomella crispa (presenting numerous varieties, and constituting the majority of the foraminifers in this deposit).
Textularia.
Amorphina (*Parker*, *MS.*).
Spiroloculina.
Quinqueloculina.
Triloculina.
Articulina.

Excepting the *Articulina*, these *Foraminifera* appear to be those commonly met with in shallow waters.—Ed. Q. G. J.

phant's tusk, and a few feet above it an indurated stratum of gypseous bands, with impressions of a shell much like a *Cyclas* or *Cyrena*, and apparently such as I found in the Dardanelles deposits. They are not drifted shells, but were tranquilly imbedded in the bed of the lake in which they lived. This band passes into beds of grey-reddish and greyish-white porous earthy marls and clay, more stratified by colour than by change of mineral character. Fig. 4 is a section of these deposits.

I wish it to be understood (continues Capt. Spratt) that I am not confounding any member of the "northern drift" with fluviatile or lacustrine deposits, although I think that has been frequently done in describing some of these late freshwater formations in which gravels are found.

But that there are evidences of a "drift" of a very late period I am aware; and I think the formation at Gallipoli (Sea of Marmora) to be an example. This is a bed of coarse gravel cemented into a hard conglomerate, in which the valves of a large species of *Dreissena* and a *Cardium* are abundantly intermixed; the mass being more than 100 feet thick. There is another fragment of it over Nazara Point, near the Dardanelles Castles, and capping the freshwater marls and sands which dip to the eastward, whilst the mass of conglomerate dips to the south-west.

On the north shore of the Sea of Marmora the "drift" is shown by a mass of cemented valves of *Driessena*, intermixed with only a few small pebbles.

T. S. October 1, 1856.]

Comparison of the Geological Features of Bulgaria and the Crimea.—I merely give these facts from a hasty examination during war; and present a series of the fossils I procured to the Society. Future researches, or the observations already made by others, but which I have not had the opportunity or time to inquire into, may perhaps explain the relative ages and peculiarities here touched upon.

Taking, however, a general view of the geological facts here briefly given, we have the secondary rocks of the Balkan terminating over the shore of the Black Sea at an elevation of nearly 2000 feet, and, with the formations lying to the north, presenting geological features similar to those of the Crimea. For, extending from the roots of the Balkan, we have the older marine Tertiaries inclining gradually from them, and succeeded by a broad district composed of reddish marls and sands, forming the Steppe of the Dobrudcha, as along the north parts of the Crimea. There is a remarkable resemblance in the red marly cliffs that extend from the Balbek in the Crimea, along the whole coast to Eupatoria, and repose directly upon the old Tertiary deposits of the Khersonese and Sevastopol, with the second group of deposits on the coast of Bulgaria. I have examined these deposits at Eupatoria, at Old Fort, at the Alma Heights, at the Katcha, and on the north side of the Balbek, and was struck with the similarity of their mineral character and with the absence of fossils, as in those of the Dobrudcha.

In Demidoff's Geological Map of the Crimea, the formation in this district is referred to a Tertiary of the Miocene age, which I much doubt; at any rate, it is numbered and coloured the same as the western half of the Khersonese, with which it certainly does not agree in geological characters or age.

Thus we have, as I have shown, a close resemblance in the deposits of the opposite shores of the Black Sea,—that is, of the Crimean and the Bulgarian coasts, although an exact geological correspondence in respect to age has not been yet made out. We have, however, an evident submarine connexion of the two mountain-ranges of the Balkan and the Tauric Peninsula, traceable across the Black Sea in a line between them. For from Odessa we have a shallow sea, increasing out from 10 to 40 fathoms only a little north of this line,—forming in fact a gradually inclined bank, until its edge descends suddenly from 300 feet to 3000 and upwards*, as on the south face of the Tauric Range; thus showing the evident continuity of the great displacements of the older formations, by which the Balkan and the Crimea were elevated. This submarine plateau or steppe is thus the link connecting the Balkan with the Caucasus as a topographical feature.

It was along the margin of this submarine plateau that the electric cable connecting Bulgaria with the Crimea was laid, so as to take advantage of its convenient depth, instead of risking an accident over the deep region of the sea in a direct line across; for the edge of the bank forms a slight curve to the north-west of the direct line.

The freshwater deposits.—The freshwater deposits overlying the marine above Baljik are deserving a special remark; because, from their position, they seem not to have been formed in a very limited lacustrine basin. Their absence, however, at Devno would rather imply the contrary; but it is possible that they have been denuded from that locality.

The real age of the overlying red marls, &c. has yet to be determined. I am led to remark, however, that they bear some resemblance to the freshwater deposits on the north shore of the Sea of Marmora, at Buyuk Tchekmejeh; and also very much so with those forming the lesser hills along the Macedonian coast, from Salonica, and also in the north end of Eubœa and the Locrian shore; fossils from which have been long since given by me to the Museum of Economic Geology†. The localities from whence these fossils came have not yet been described‡; but the corresponding deposits are noticed as a group of "brownish sandy marls and gravels" overlying the Eocene freshwater beds of Samos and Eubœa, in a paper by me, published in the Geological Society's Journal § of 1847.

* Since ascertained to descend abruptly from 50 to 500 or 600 fathoms, or nearly 4000 feet in depth: and in the middle of the western basin of the Black Sea the depth has been ascertained by me to be nearly 7000 feet, or nearly twice that of the Tauric range in the southern part of the Crimea. [T. S., October, 1856.]

† Amongst them is *Limnæa Adelina* in great abundance.

‡ Since this paper was read, Capt. Spratt has communicated a description of the deposits here referred to, in his memoir "On the Freshwater Tertiaries of Eubœa," &c., read Dec. 17, 1856.—Edit. Q. G. J.

§ Vol. vii. p. 70.

I had at that time found no fossils in any of these largely-developed deposits of red sandy marls, &c.; but I subsequently identified their freshwater origin, as evidenced by the fossils found near Talanta on the Locrian coast, where all the lesser hills are composed of these deposits, also at Thermopoli, the valley of Xero Khori (Eubœa), and along the Macedonian coasts up to Thessalonica, where I found them to contain freshwater fossils, the bones of a Snake (afterwards given to Prof. Owen), and also some Mammalian bones, which were sent to the Museum in Jermyn Street*. The localities deserve a brief description (which I hope to give hereafter), from their evident connection with the Pleiocene freshwater deposits of Lycia, Rhodes, and Cos, and with some in Crete also; and, I think I may add further, with the extensive freshwater deposits that occur on both sides of the Dardanelles from the Troad to Gallipoli, and along the coast of the Sea of Marmora, where they contain thin beds of lignite† in some places, as at Buyuk Tchekmejeh.

Almost all the Thracian Peninsula, indeed, is composed of deposits of freshwater origin, consisting of brown and grey marls and sandstones, or sands, lying nearly horizontal and attaining a thickness apparently of fully 500 and 600 feet; and, from their fossils, they seem to be of a type corresponding with the latter or Pleiocene freshwater deposits on the western side of the Archipelago, in Eubœa, and Macedonia, and in Rhodes, &c. on the south.

The specimens sent to the Society from the deposits on the north side of the Dardanelles will best determine this; they consist of a *Cyclas*, *Paludina*, *Planorbis*, *Melanopsis*, &c., and there is a cast of some large Seed-vessel with them, resembling a pine-fruit; this was procured from above Meitos. The deposits immediately over the Europe Castle of the Dardanelles, Killid Bahr, contain fossils in the greatest abundance; but, excepting the species of *Melanopsis* herewith sent, these are generally too fragile to be preserved perfect.

The inquiry as to the boundaries of these freshwater lakes, if they were a chain of lakes, or its range and extent if there were but one large lake, still forms a very interesting subject of research connected with the geology of the Egean, the Sea of Marmora, and the Black Sea.

Post-Tertiary or Recent deposits.—On several parts of the shores of the Dardanelles there are the remains of a recent marine deposit, indicative of a change in the present sea-level since it succeeded the Pleiocene lake above referred to. For at the base of the hills north of Meitos, and on the opposite coast, there are Oyster-beds at an elevation of about 40 feet above the sea.

These Oysters correspond exactly with those now existing plentifully in the channel near Meitos, which are largely exported to Con-

* These fragmentary mammalian bones were submitted by Prof. E. Forbes to Prof. Owen, but were not determinable. The ophidian vertebræ have been described in a paper read before the Society by Prof. Owen, Jan. 7, 1857, who referred them to an extinct, and previously undescribed genus, *Laophis*.—Edit. Q. G. J.

† For a notice of the occurrence of lignites in the north-western districts of Asia Minor, see this Journal, no. 45, p. 1.—Edit. Q. G. J.

stantinople, &c. The sea-level no doubt was 15 or 20 feet higher than the Oyster-bank, as this does not appear to have been a beach.

At Gallipoli, also, there are the remains of an old sea-bed, forming the crest of the Point near the Lighthouse, and containing great quantities of a large *Cardium*, apparently the existing species, and with it I found intermixed the detached valves of a *Dreissena* (see specimens sent to the Society), which were probably washed out of the freshwater deposits that this recent sea-bed overlies: its elevation is about the same as of that at Meitos.

Appendix.

Mr. J. Morris has kindly assisted the Editor in drawing up the following rough list of the fossils accompanying Capt. Spratt's Notes on the Geology of Varna, the Bulgarian Coast, and the Dardanelles.

1. *Fossils from Allahdyn.* (See page 73.)

Mollusca.

Teredo?
Ostræa latissima, *Deshayes.*
Ostrææ; small species.
Anomia.
Plicatula?
Pecten; two species.
Terebratula; resembling *T. carnea.*

Annelida.

Vermicularia; like *V. Bognoriensis.*
Serpula.

Entomostraca.

Bairdia subdeltoidea.
Cythere, sp.

Foraminifera.

Nummulina distans, *Deshayes.*
N. (Assilina) granulosa, *D'Archiac*; (nearly smooth var., rare).
Operculina canalifera, *D'Archiac*; (very fine specimens).
Orbitoides Fortisii, *D'Archiac.*
Cristellaria rotulata, *Lamarck*, sp.
Truncatulina vulgaris, *D'Orb.*
Nonionina communis, *D'Orb.*
Rosalina ammonoidea, *Reuss.*
Rotalia, sp.

2. *Fossils from Varna Bay.* (See page 73.)

Trochus.
Buccinum or Nassa.
Cerithium.
Lucina.
Modiola (a ribbed species).
Pecten.
Chama.
Casts of small univalves and bivalves.
Cardium (*in the oolitic rock*).

3. *Baljik; greyish crystalline limestone.*

Planorbis.
Limnæa.
Hydrobia?
Helix? (fragment).
Cyrena? (fragment).

4. *Baljik; soft white calcareous rock.*

Helix; a small depressed species.

5. *Baljik; soft white calcareous rock.*

Mactra.

6. *Baljik.*

Helix; (in the same packet as No. 5, but the matrix of the *Helices*, as seen by their contents, was sandy).

7. *Fossils from the Dardanelles.* (*Hard brownish rock.*)

Cypridæ.	Paludina? and *Opercula*?
Cardium.	Unio?

8. *Dardanelles*; (*grit*).

Paludina.	Unio.	Cyrena?

9. *Dardanelles*; (*sandy rock*).

Paludina.	Cyrena.

10. *Dardanelles*; (*fissile brownish calcareous sandstone*).

Cypridæ.	Cardium.	Unio.

11. *Dardanelles*; (*rock similar to No.* 10, *but more crystalline*).

Ligneous fossils (referred to above, p. 81).

12. *Dardanelles*; *Europe Castle.*

Melanopsis (see page 81).

13. *Dardanelles.* (See page 82.)

Cardium.	Dreissena.

On the CRETACEOUS FOSSILS *of* ABERDEENSHIRE. By J. W. SALTER, Esq., F.G.S. *With a Note on the position of the Chalk-flints and Greensand*; by W. FERGUSON, Esq., F.G.S.

[Read June 18, 1856*.]

[Plate II.]

No apology need be offered for presenting to the Society a list of the cretaceous fossils discovered in Aberdeenshire by Mr. W. Ferguson, and figures of the new and characteristic species; for there are many points of interest connected with the former extension of the cretaceous rocks from Sweden over the northern part of Britain, and thence to the north of Ireland, which must receive illustration by the recording of such facts as those which he has observed. (See Appendix, p. 88.)

His own impression is, that there might be a possibility of the fossils in question having been drifted to their present position. But,

* For the other communications read at this Evening's Meeting, see Quart. Journn. Geol. Soc. vol. xii. p. 384, &c.

setting aside the improbability that masses of soft sandstone containing still perfectly preserved casts should be drifted from any known locality in Britain *northwards*, the point of greatest interest is that the indications are not only of the near neighbourhood of some members of the cretaceous formation, but actually of the "Upper Greensand" itself,—a formation not known to exist further north in Britain than Cambridgeshire. It is probably, however, represented in Antrim*.

There appears to me every reason to believe too, that the Greensand is *in situ*, occurring as it does at a low level compared with those local accumulations of Chalk-flints which are described in Mr. Ferguson's memoir on the subject †.

The following list of fossils will serve to show the geographical range of the species, as well as to identify the formations. From the flints of the chalk-formation we are able to add three or four interesting fossils to the British list;—one is the *Lima elegans* of Nilsson, a species figured also by Hisinger. The occurrence of *Crania costata, Kingena lima, Spondylus striatus, Inoceramus striatus, Micraster cor-anguinum*, &c., leaves no doubt as to the age of the formation.

And the presence in the Greensand of such species as *Galerites castanea, Arca carinata, Pinna tetragona*, and especially the *Thetis major*, indicates as clearly that it is the Upper, and not the Lower, Greensand, which here underlies the Chalk. Nilsson and Hisinger, in their enumeration of the Cretaceous fossils of Scania, give many which are characteristic of the chalk, and mention some also which are from the green-sand ("arenâ viridi"). Amongst the former the *Lima* (*Plagiostoma*) *elegans* belongs to the chalk of Balsberg, associated with *Inocerami*, as in the Scottish locality.

In the hard lower siliciferous chalk of Sweden, the *Lima semisulcata, Pecten orbicularis*, Sow., and the so-called *P. corneus* occur. As this rests on, and passes down into Greensand full of fossils (amongst others the *Belemnitella mucronata*), there is probably the same succession on the south coast of Sweden, which we are now enabled to indicate for the East of Scotland; and the latitudes are nearly the same.

List of Fossils found in Chalk-flints from Aberdeenshire.

[*Note.* + signifies the more abundant species; — rare ones.]

Ventriculites, several species; fragments	+	Bogingarry, &c.
Parasmilia centralis, *Mant.*	+	Bogingarry.
Micraster cor-anguinum, *Leske*	+	Bogingarry.
Ananchytes lævis, *Deluc*	—	Bogingarry.
Galerites (Discoidea) subuculus, *Leske*	—	Moreseat.
Cidaris clavigera, *Mant.*, spine and plate	—	Bogingarry, Cruden.
——, sp.	—	Smallburn.

* The collections of Mr. James M'Adam of Belfast have unfortunately not yet been made available. The occurrence, however, of *Exogyra columba* in the upper beds has been noted by Col. Portlock in his work on Tyrone. There seems little doubt of the presence of the Upper Greensand in North Ireland.

† Phil. Mag. 1850, p. 430.

Semiescharipora mumia, *D'Orb.* Pl. II. fig. 1	—	Bogingarry.
Flustrellaria dentata, *D'Orb.* Pl. II. fig. 2	—	Bogingarry.
Crania costata, *Sow.*	—	Bogingarry.
Terebratula, sp.	—	Moreseat.
Kingena lima, *Defr.*	+	Dudwick.
Rhynchonella Mantelliana, *Sow.*	—	Moreseat.
Pecten; one or two species	—	Smallburn.
—— orbicularis, *Sow.*	—	Smallburn.
Spondylus striatus, *Sow.*	+	Bogingarry.
Inoceramus striatus, *Mantell*	—	Bogingarry.
——, hinge of	—	Bogingarry.
—— Brongniarti, *Sow.*	+	Bogingarry.
Lima elegans, *Nilsson.* Pl. II. fig. 3	—	Moreseat.

Fossils in Upper Greensand at Moreseat.

Microbacia coronula, *Goldf.*	—
Ananchytes, sp.	—
Toxaster, sp. Pl. II. fig. 4	—
Galerites castanea, *Brongn.*	—
—— (Discoidea), sp.	
Diadema, small species	—
Rhynchonella compressa, *Lam.*	+
Pecten (probably the *P. corneus* of Nilsson, not of Sow.)	+
Lima semisulcata, *Sow.*	—
Avicula simulata, n. sp. Pl. II. fig. 5	—
Pinna tetragona, *Sow.*	+
Arca carinata, *Sow.*	+
Pectunculus umbonatus, *Sow.*?	—
Limopsis texturata, n. sp. Pl. II. fig. 6	+
Cyprina Fergusoni, n. sp. Pl. II. fig. 7	+
Dentalium cœlatulum, n. sp. Pl. II. fig. 8	—
Trochus; a small elongated form	—
Ammonites Selliguinus, *Brong.*?	—
——, sp. Pl. II. fig. 10	—
——, sp. allied to *A. Pailletteanus, D'Orb.* Pl. II. fig. 9	+

I am indebted to my friend Mr. W. H. Baily, of the Geological Survey, for several of these identifications; and he has also taken the trouble to describe some of the following forms.

Description of some of the Fossils from the Chalk-flints.

1. Lima elegans. Pl. II. fig. 3.

Plagiostoma. Nilsson, Petrific. Suecica, pl. 9. f. 7. Hisinger, Lethæa Suec. pl. 15. f. 10.

Mr. Baily has identified this beautiful species. Our specimen agrees almost exactly with that of Nilsson and Hisinger; although their figures are somewhat coarse representations.

Loc. Moreseat in chalk-flint. (Nilsson's specimens were from Balsberg, where chalk-fossils abound.)

The *Bryozoa* figured are new to Britain; one belongs to the group *Eschariporidæ,* and the other to the *Flustrellaridæ.*

2. Semiescharipora mumia. Pl. II. fig. 1.

D'Orbigny, Pal. Franç. Terr. Crétacées, vol. v. pl. 718. f. 10.

Both the upper and under surfaces are preserved; the circumscribed area of the fossettes, and the position of the two accessory pores *in a line with* the cell-mouth are good characters; the coarse tuberculation of the lower side helps also to identify it.

Loc. Bogingarry; in chalk-flint.

3. Flustrellaria dentata. Pl. II. fig. 2.

D'Orb, *l. c.* pl. 725. f. 19.

This is, without much doubt, referred to *Flustrellaria*; and the very irregular and dentated outline of the rhomboidal cells will, I think, safely connect it with *F. dentata*, although we have not the upper surface.

Loc. Bogingarry, in chalk-flint.

Description of some of the Fossils from the Upper Greensand.

4. Toxaster, sp. Pl. II. fig. 4.

This form, though too imperfect for description, appears to be distinct from either of the other two described British species. It is more depressed than either *T. Greenovii* or *T. Fittoni*, Forbes. It has a shallower sulcus than the former, and the vertex is more central than in the latter. If new, it might be called *T. Scoticus.*

5. Avicula simulata, Baily. Pl. II. fig. 5.

We have only the left valve: it is obliquely ovate and moderately convex; auricle small; umbone prominent; costæ about 14, radiating, unequal and distant, with fainter ones in the interstices, crossed by well-marked concentric lines of growth.

This specimen is a cast of the interior of a single left valve, with the smaller ear broken away; it is otherwise well preserved. It bears some resemblance to *Avicula inæquivalvis*; but differs in its greater obliquity. It is very distinct from the only other Upper Greensand species, *A. gryphæoides*, as well as from *A. anomala*, found in the greensand of Blackdown (W. H. B.).

6. Pectunculus umbonatus, Sow.?, Min. Conch. pl. 472. f. 3.

Sowerby's figure has so much coarser ribs than our specimen, which, though only an internal cast, shows numerous striæ on the margin, that it is not at all certain they are identical. Goldfuss's figure (Petref. pl. 126. f. 2) seems intermediate in this respect.

The interior cast of *P. subconcentricus*, Lamarck, as figured by D'Orbigny (Terr. Crét. pl. 306. f. 12–19), would much resemble our shell; but that species was wider in proportion, even in the young state.

7. Limopsis texturata, Salter. Pl. II. fig. 6.

Obliquely ovate, considerably longer than wide, and with a convex produced beak; radiated by 14 or 15 coarse sharp-edged costæ, which are themselves covered by close sharp lines of growth, decussated by longitudinal striæ. An intermediate narrow rib lies between each pair of costæ. The shell seems to have been thick, the posterior side steeply bent inwards, and probably (like the anterior slope) free from ribs. The hinge-line had but few teeth, and only at the outer angles.

8. CYPRINA FERGUSONI, Salter. Pl. II. fig. 7.

Moderately convex, rounded, with an elevated and pointed beak, which is lateral and overhangs a shallow lunette; anterior and posterior sides rounded, the posterior slope arched, convex, not at all angular or flattened above. Surface striated concentrically by close sharp lines, and a few more prominent ridges of growth. Height, 1 inch; length, 1 inch; depth of two valves united, $\frac{1}{2}$ inch.

Most like in general shape to *Venus Vassiacensis,* D'Orb. (an internal cast). But it is clearly not a *Venus,* as it has posterior lateral teeth. *Cyprina consobrina,* D'Orb., is also like, but is described as smooth, or nearly so. Our shell is closely and sharply striate, and has not a very large lunette.

9. DENTALIUM CŒLATULUM, Baily. Pl. II. fig. 8.

Elongated; slightly curved, and gradually tapering posteriorly. The surface, which is preserved in a sandstone-mould, is ornamented with both concentric and longitudinal striæ closely set, producing a finely reticulated appearance. Aperture somewhat oval.

It differs from the Gault species *Dentalium decussatum,* Sow., or its cast, *D. ellipticum,* in being straighter, and in having its surface more finely reticulated, as well as in the absence of the more prominent striations which occur on the posterior portion of that species (W. H. B.).

The two following species of *Ammonites* are figured, but are not sufficiently perfect to make it worth while to give them names:—

10. AMMONITES, sp. Pl. II. fig. 9.

Discoid, whorls somewhat depressed and crossed by numerous strong flexuous ribs, sometimes simple, but mostly dividing into two about the middle of the side, and continuing over the rounded back.

It is distantly allied to *A. Pailletteanus,* D'Orb. (Terr. Crét. pl. 102), but that species has narrow ribs, none of which are distinctly bifurcated (W. H. B.).

11. AMMONITES, sp. Pl. II. fig. 10.

Discoid, whorls moderately rounded, with many flexuous ribs which are prominent towards the umbilicus and bear a small compressed tubercle at the point of bifurcation. The ribs are frequently trifurcate, and one of them again branched from about the middle of the side, so as to form groups of three or four; umbilicus small.

Apparently a smaller species than the last; it is allied to *A. Jeannotii,* D'Orb., *l. c.* pl. 56,—a species which has considerably closer ribs, and occurs, I believe, in the English Gault (W. H. B.).

Note on the Chalk-flints *and* Greensand *found in* Aberdeenshire. By W. Ferguson, Esq., F.L.S., F.G.S.

Water-worn flints are found mingled with other pebbles for the distance of about three miles along the shore north and south of Buchanness, on the eastern coast of Aberdeenshire; especially between the Black Hills on the north and Stirling Hill on the south, wherever the rocks admit of a beach. Similar flints are found, though sparingly, on Stirling Hill; and they occur more plentifully on the Black Hill and the neighbouring hill of Invernettie, almost covering the surface; they are traceable also along the ridge, of which these last-mentioned hills are the eastern termination, at several points to a distance of five miles inland from the sea. Here they occur at the extreme verge of the parish of Old Deer, and are well seen upon the farm of Bogingarry, on the estate of Kinmundy, where they are closely packed in a clayey matrix, and contain numerous organic remains, chiefly in the condition of casts and impressions.

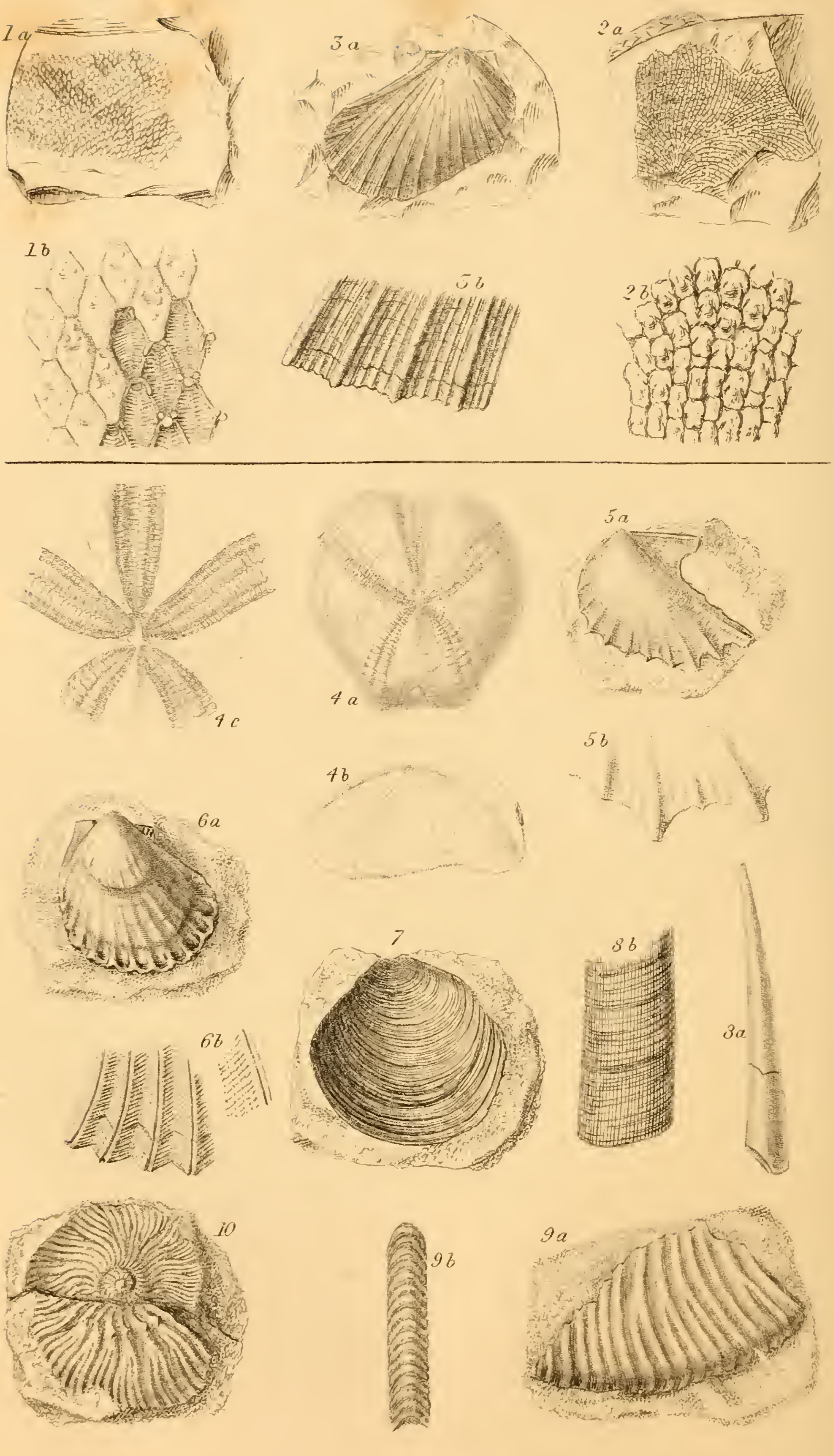
Near Peterhead also (not far north of Buchanness) flint-casts of *Echini* and other fossils are very abundant. Flints are also found on the surface of the hill of Skelmuir, adjoining Bogingarry; and to the south-west on the hill of Dudwick in the parish of Ellon. This seems to be their southernmost limit. In these localities the flints are angular.

According to Mr. Christie* chalk-flints are found in the drift on the high grounds between Turriff and Delgaty Castle (Aberdeenshire), and among the shingle at Boyndie Bay, west of Banff.

The Greensand was found at Moreseat, in the parish of Cruden, south-west of Buchanness and about four miles from Kinmundy above-mentioned. It was first met with in making an excavation for a water-wheel; and was again found about 400 yards to the north-east of this point in digging a ditch to drain a field lately reclaimed from the moss. Here it was from 1 to 3 feet below the surface, and traceable in the ditch for more than 100 yards. The ditch was 7 feet deep, and the section presented irregular layers of unctuous tough clay, of a dark-brown colour and soapy feel, and containing thin layers or patches of a compact sandstone. These layers were not continuous; they graduated into each other, thinned out, disappeared, and reappeared most confusedly. They were much inclined, dipping to the south. The whole mass had much the appearance of having been drifted; although, from the nature of the material, and the state of preservation in which the shells are found, it does not appear as if it could have been transported far. The sandstone is soft when newly dug, but hardens on exposure to air, and becomes light-coloured in drying. When wet, it presents a mottled appearance, the colouring being greenish; when dry this almost disappears. The exterior surface of the masses are reddened with iron.

Many of the organic remains in this sandstone are casts, and occur

* Edinburgh New Philos. Journ. 1831, vol. x. p. 163.



Fossils in the Chalk-Flints and Upper Greensand

OF ABERDEENSHIRE.

J. De C. Sowerby fec^t

both on the outside of the masses and within. In a few instances the shelly matter is preserved. Flattened spatangoid urchins are the most abundant of the fossils.

[See Proceedings Phil. Soc. Glasgow, 1849, vol. iii. No. 1. p. 33, &c.; and Phil. Mag. 1850, vol. xxxvii. p. 430, &c.]

EXPLANATION OF PLATE II.

[Figs. 1–3 are from the Chalk-flints, and figs. 4–9 from the Upper Greensand, of Aberdeenshire.]

Fig. 1 *a*. Semiescharipora mumia, *D'Orb.* 1 *b*. Portion of the lower surface magnified;—some of the cells are broken away on the right, and show impressions of the ornamented upper surfaces.

2 *a*. Flustrellaria dentata, *D'Orb.* 2 *b*. Portion of the under surface magnified.

3 *a*. Lima elegans, *Nilsson.* 3 *b*. Portion of exterior magnified.

4 *a*. Toxaster, sp.; internal cast. 4 *b*. Side view of the same. 4 *c*. Portion magnified.

5 *a*. Avicula simulata, *Baily*; cast of the interior. 5 *b*. Portion of the same magnified.

6 *a*. Limopsis texturata, *Salter*; cast of the interior. 6 *b*. Portions of the exterior magnified.

7. Cyprina Fergusoni, *Salter*; cast of the exterior. (Some perfect internal casts have been omitted by accident from the plate.)

8 *a*. Dentalium cœlatulum, *Baily.* 8 *b*. Portion of the exterior magnified.

9 *a*. Ammonites, sp., fragment. 9 *b*. Edge-view of the same.

10. Ammonites, sp. The upper portion is only an impression of the outside in the matrix.

On the CORRELATION *of the* EOCENE TERTIARIES *of* ENGLAND, FRANCE, *and* BELGIUM. By J. PRESTWICH, Esq., F.R.S., F.G.S.

[Read June 18, 1856*.]

CONTENTS.

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* For the other communications read at this Evening's Meeting, see Quart. Journ. Geol. Soc. vol. xii. p. 384, &c.

Part II.*—The Paris Group (*continued*).

§ 1. *The Bracklesham Sands and Calcaire grossier; general features and shells common to the two deposits.*

In my paper of June 1854 I expressed an opinion that the lower members of the Sables Inférieurs of France,—the Landenian and Lower Ypresian Systems of Belgium,—and the Thanet Sands, Woolwich series, and London Clay of England, formed a natural and well-marked geological division of the Eocene Tertiaries, to which, as their development is most complete in this country, I proposed the term of the "London Tertiary Group."

Above this group commences a new order of things; the rich fauna of the Calcaire grossier extends over the French, Belgian, and English areas, accompanied by a profuse exhibition of nummulites—a feature the more marked from the absence of these Foraminifera in the underlying London Group. For this next overlying series I have proposed the name of the "Paris Tertiary Group" †.

The commencement of the Paris Group is in England represented by the unfossiliferous Lower Bagshot Sands ‡, in Belgium by the partially fossiliferous Upper Ypresian System, and in France by the nummulite-bearing Lits coquilliers and associated sands of M. D'Archiac, or the Glauconie moyenne of M. Graves. With the evidence bearing on the synchronism of these beds I concluded my former paper, and I now propose to consider the exact correlation we should assign to the Bracklesham Sands and to the Barton Clay.

It so happens that where the Bracklesham series is well exposed and easily accessible, as at Alum Bay and in the opposite Hampshire Cliffs, it contains no organic remains, with the exception of the perishable impressions of shells in the soft sandy strata near Christchurch. In the cliffs at White Cliff Bay,—where, on the contrary, the strata are in parts very fossiliferous,—the beds are much masked by the falling of the cliffs, and their separation from the Barton Clays is not so well seen as at the former places; and, excepting a few leading species, the fossils have not been worked out with that care and attention which have been bestowed on them at Bracklesham. At this latter place, however, no superposition is visible. The beds crop out below high-water mark in the open cliffless bay for the distance of above two miles; and the fossils have to be picked up or dug out, when, after favourable conditions of wind and tide, the surface of the

* For Part I., see Quart. Journ. Geol. Soc. vol. xi. p. 206, &c.; where will also be found a section (pl. 8) partially exhibiting the range of some of these divisions. I have there used the old term "Grès de Beauchamp" instead of "Sables moyens."

† Its upper limits I leave as a matter of future inquiry.

‡ I had applied the term of the Lower Bracklesham Sands to the 100 feet of yellow unfossiliferous sands (No. 5 of my White Cliff Bay section, Quart. Journ. Feb. 1846) overlying the London Clay in the Isle of Wight; and I took them then, as I still do, to be the equivalent of the Lower Bagshot Sands. I think, however, it will be more convenient to confine the term of the Bracklesham series to the overlying fossiliferous strata, and only to call the lower unfossiliferous sands the Lower Bagshot Sands.

beds is free from the sand which at other times often covers them. Under these circumstances it would be difficult to say whether, on the one side, any of the Lower Bagshot Sands (supposing they might be here fossiliferous), or, on the other side, some portion of the Barton Clays, may not have contributed to enrich the Bracklesham collections. Not that I believe this foreign element to prevail to any extent; still it is possible that some fossils, especially of the adjacent Barton series, may under such circumstances have been associated with those of the Bracklesham Sands*. The error, however, if it do exist, is probably not a very serious one, and will not materially affect the question we have in view; whilst, on the other hand, we may feel assured that, thanks to the able and indefatigable researches of Mr. Edwards, the fossil shells of these beds have been worked out and determined with an accuracy and to an extent in no instance surpassed and rarely equalled†.

In a paper read in November 1847 I referred the Bracklesham Sands to the lower part of the Calcaire grossier—a position which I yet partly assign to them, though I am now disposed to give them a much greater extension. There are many points to be noted in common between these Bracklesham Sands and the lower Calcaire grossier. In the one as in the other, green sands are more or less mixed; whilst at the base of the series, both in England and France, there is an occasional band of small flint pebbles, that, taken together with a certain prevailing coarseness of the sands, form physical features which, although not very strong, are sufficiently persistent and sufficiently on the same plane to give a distinctive character to the commencement of the Calcaire grossier series both in this country and in France. With these is combined the appearance of a distinctive group of organic remains that continues in successive and changing phases through the Middle Eocenes up to the period of the Sands of Fontainebleau and the Limburg beds, when we find the fauna of this Paris group replaced by another, still of the same type, but equally distinctive in individual characters, as the former is from that of the London Group which it had supplanted. In this paper I will confine myself to the inquiry connected with the correlation only of the marine beds of the Bracklesham and Barton periods, leaving the inquiry connected with the freshwater conditions subsequently prevailing in part of the latter to a future occasion. For the lower division of the Eocene series, or the London Group, I took the strata in this country as types. With regard, however, to the Middle Eocenes, they are so well developed in France, have been so admirably worked out by Cuvier and Brongniart and many subsequent observers, and

* As, however, the greater part of the fossils are obtained from the centre of the Bay—from those beds containing the *Venericardia planicosta*, *Cerithium giganteum*, and *Voluta spinosa*, or from others closely associated with them—there can be little doubt that the great bulk of the organic remains procured from Bracklesham Bay belong truly to the Bracklesham series.

† The collection of Mr. Bowerbank is also very extensive, as likewise was that of the late Mr. Dixon, to whom we are indebted for an important list of all the fossils known to occur at Bracklesham, with valuable monographs on the several classes of organic remains contributed by various scientific friends. See Dixon's 'Geology of Sussex,' London, 1850.

are so singularly rich in organic remains, that they there afford on all points the best types to which to refer the English and Belgian beds. The divisions I have adopted are those of M. D'Archiac, modified in parts by those of M. Chas. D'Orbigny and of M. Graves, the latter of whose valuable work on the Beauvais and Chaumont district affords the most complete data for the comparison of the French with the English Eocene faunas.

In comparing the fauna of the several deposits I have confined myself as before almost entirely to the *shells* alone, as these organic remains are not only far more numerous than any others, but have been much more fully worked out. Still so much remains to be done even with the shells, that M. Graves and many other French geologists have abstained from defining the exact number of species common to the several deposits. Nevertheless I believe that the lists they give are sufficiently complete to guide us at all events in a preliminary inquiry and to show the direction which the argument should take. This is the more essential, as with a perfect identity in many common fossils, there are nevertheless important differences in the totality of the faunas of the French and English formations, whilst in lithological structure and thickness they also present but few points of resemblance.

The Bracklesham Sands are about 500 feet thick in the Isle of Wight, whereas the Calcaire grossier does not exceed, taking each division of it at its fullest development, 140 to 150 feet; but as the several divisions are not all in full force in any one place, the actual average thickness rarely exceeds 100 feet. The French formation is however much richer than the English in organic remains. M. Graves enumerates a total of 824 species, whereas at Bracklesham there are only 451 known species. Amongst the latter there are 368 molluscs, and in the former 651. Of this large number only 144 species have been at present determined to be common to the two countries, and yet there can be very little doubt that these formations are perfectly synchronous; the difference, I believe, arising both from the different geographical conditions which commenced to obtain at the period of the London Clay, and also to the differences of the sea-beds of the two regions. The general list of the Bracklesham fossils I have given in a previous paper*. I now annex a list of all the Bracklesham shells identified with French species, with columns showing the extent of their range either in the Calcaire grossier or in higher or lower beds†. Although the several divisions of the Calcaire grossier fossils pass one into another, still the species are differently distributed, and there is a marked distinction as a group between the fossils of the lower and upper zones: they are far less numerous in the latter, and some few are peculiar to each. In the following Table I have therefore found it convenient to take the two lower and the two upper divisions separately.

* Quart. Journ. Geol. Soc. vol. x. p. 450.

† Notwithstanding every care, I feel satisfied that both this and the Barton list (p. 118) yet require considerable correction. Of their essential truth I, however, feel more convinced.

List of those Bracklesham Shells which occur also in the Paris Tertiaries, showing their vertical distribution in the latter series.

[The chief authorities for the species in France are the works of Deshayes, Graves, and D'Archiac; in England, Edwards, Morris, and Dixon.]

Bracklesham Mollusca. [This list contains some species which do not appear in my former general Bracklesham list; and in some other respects also it is corrected.]	Sables Inférieurs, —the three lower divisions.	Lits Coquilliers and Glauconie Moyenne.	Calcaire grossier.		Sables Moyens.
			The two lower divisions.	The two upper divisions.	
Beloptera belemnitoides, *Blainv.*	......	......	*		
Belosepia Cuvieri, *Desh.*	......	......	*		
—— sepioidea, *Blainv.*	......	*?	*	...	*
Nautilus ziczac, *Sow.*	......	*			
Acteon (Tornatella) sulcatus, *Lam.*	......	*	*		
Adeorbis (Turbo) planorbicularis, *Desh.*	......	*	*	...	*
Ampullaria depressa, *Sow.* (Natica intermedia, *Desh.*)	......	*	*	*	
—— patula, *Lam.*	......	*	*		
Ancillaria buccinoides, *Lam.*	......	*	*	*	*
—— canalifera, *Lam.*	......	*	*	*	*
Bifrontia bifrons, *Lam.*	......	*	*		
—— disjuncta, *Desh.*	......	......	*	...	*
—— Laudinensis, *Desh.*	......	*			
—— marginata, *Desh.*	......	......	*	*	*
Buccinum stromboides, *Lam.*	......	*	*	*	*
Bulla Defrancii, *Sow.* (B. lignaria, var., *Desh.*)	......	*	*	...	*
—— attenuata, *Sow.*	......	*			
Cancellaria costulata, *Lam.*	......	......	*	...	*?
—— evulsa, *Brand.*	......	......	...	...	*
Cassidaria nodosa, *Brand.* (C. carinata, *Lam.*)	......	*	*	...	*
Cerithium angulatum, *Brand.* (C. hexagonum, *Lam.*)	......	*	*	*?	
—— calcitrapoides, *Lam.*	......	......	...	*	*
—— Cordieri, *Desh.*	......	......	...	...	*
—— cristatum, *Desh.*	......	......	*	*	*
—— echidnoides, *Lam.*	......	......	*	*	*
—— elegans, *Desh.* (*a*)					
—— Geslini, *Desh.*	......	*			
—— giganteum, *Lam.*	......	......	*		
—— lima, *Desh.* (*a*) (concinnum, *Charlesw.*)?					
—— muricoides, *Lam.*	......	......	*	*	
—— papale, *Desh.*	......	*			
—— semicoronatum, *Lam.*	......	......	*	*	*
—— semigranulosum, *Lam.*	......	*	*	*	*

(*a*) only in higher beds in France.

Table (continued).

Bracklesham Mollusca.	Sables Inférieurs, —the three lower divisions.	Lits Coquilliers and Glauconie Moyenne.	Calcaire grossier.		Sables Moyens.
			The two lower divisions.	The two upper divisions.	
Cerithium unisulcatum, *Lam.* ...	......	*	*	...	*
Conus deperditus, *Brug.*	......	......	*		
—— antediluvianus, *Desh.*	......	......	*	*	
Cyprea inflata, *Lam*...............	......	......	*		
—— (Ovula) tuberculosa, *Desh.*	......	*			
Delphinula Warnii, *Desh*..........	......	......	*		
Dentalium eburneum, *Lam*.......	......	......	*	*	*
Fasciolaria uniplicata, *Lam*.......	......	*	*		
Fusus bulbiformis, *Lam.*	*	*	*	*	*
—— Gothicus, *Desh.*	......	......	*		
—— longævus, *Lam.*	*	*	*	...	*
—— Noæ, *Lam.*	......	......	*		
—— polygonus, *Lam.*	......	......	*	...	*
—— porrectus, *Brand.*	......	*	*		
—— rugosus, *Lam.*	......	*	*		
—— scalaris, *Lam.* (serratus, *D.*)	......	......	*	...	*
—— unicarinatus, *Desh.*	......	*			
Hipponyx cornucopiæ, *Defr.* ...	......	......	*	*	*
Infundibulum (Calyptræa, *Lam.*) trochiforme, *Sow.*	*	*	*	*	*
Marginella eburnea, *Lam.*	......	......	*	*	*
—— ovulata, *Lam.*	......	*	*	*	*
Melania costellata, *Lam.*	......	*	*	*	*
—— levigata, *Desh.*	......	......	*		
—— marginata, *Lam.*	......	*	*	*	*
Mitra labratula, *Lam.*	......	......	*	...	*
Murex asper, *Brand.* (M. tricarinatus, *Lam.*)	......	......	*	*	*
——(Fusus, *Lam.*) minax, *Brand.*	......	......	*	...	*
Natica epiglottina, *Lam.*	......	*	*	*	*
—— hybrida, *Lam.*	......	*	...	...	*
—— labellata, *Lam.*	......	*	*	*	*
—— lineolata, *Desh.* ?	......	......	...	...	*
—— ponderosa, *Desh.* ?	......	......	...	...	*
—— scalariformis, *Desh.*	......	......	*		
—— sphærica, *Desh.*	......	......	*	...	*
—— Willemettii, *Desh.*	......	......	*	...	*
Nerita tricarinata, *Lam.*	......	*			
Niso (Bonellia) terebellata, *Desh.*	......	......	*		
Orbis (Trochus) patellatus, *Desh.*	......	......	...	...	*
Parmophorus elongatus, *Lam.* .	......	......	*		
Phorus (Trochus) agglutinans, *L.*	......	*	*		*
Pileopsis squamæformis, *Lam.*...	......	*	*	...	*
Pleurotoma acutangularis, *Desh.*	......	*	*		
—— dentata, *Lam.*	......	*	*	*	*
—— granulata, *Lam.*	......	......	*	...	*

Table (continued).

Bracklesham Mollusca.	Sables Inférieurs,—the three lower divisions.	Lits Coquilliers and Glauconie Moyenne.	Calcaire grossier.		Sables Moyens.
			The two lower divisions.	The two upper divisions.	
Pleurotoma inflexa, *Lam.*	......	*	*	...	*
—— prisca, *Brand.*	......	......	*	...	*
—— textiliosa, *Desh.*	......	......	...	...	*
—— transversaria, *Lam.*	......	......	*		
Pseudoliva (Buccinum, *Desh.*) obtusa, *Sow.*	......	*	*		
—— semicostata, *Desh.*	*				
Pyrula lævigata, *Lam.*	......	......	*	*	*
—— nexilis, *Lam.*.................	......	......	*	...	*
—— tricostata, *Desh.*	......	*			
Ringicula ringens, *Lam.*	*	*	*	*	*
Rissoa (Melania) cochlearella, *Lm.*	......	*	*		
Rostellaria ampla, *Brand.* (R. macroptera, *Lam.*)	......	*	*		
Scalaria acuta, *Sow.*	......	......	*		
—— tenuilamella, *Desh.*	......	*	*		
Sigaretus canaliculatus, *Sow.* ...	......	......	*	*	*
Solarium canaliculatum, *Lam.*...	......	......	*	...	*
—— patulum, *Lam.*...............	......	......	*		
—— plicatum, *Lam.*..............	......	......	*	...	*
—— spiratum, *Lam.*..............	......	*	*	...	*?
Strepsidura turgida, *Brand.* (Fusus ficulneus, *Lam.*)	......	*	*	...	*
Terebellum fusiforme, *Lam.*......	......	*	*		
Turbo (Rissoa) plicatus, *Desh.*...	......	......	*		
Turritella abbreviata, *Desh.*	......	......	*	...	*?
—— carinifera, *Desh.*	......	*	*		
—— fasciata, *Lam.*	......	......	*	*	*
—— imbricataria, *Lam.*	*	*	*		
—— intermedia, *Desh.*............	......	*	*	*	*
—— multisulcata, *Lam.*	......	......	*		
—— sulcata, *Lam.*	......	......	*	...	*?
—— sulcifera, *Desh.*...............	......	......	*	...	*
—— terebellata, *Lam.*	......	......	*		
Voluta angusta, *Desh.*	......	*			
—— Branderi, *Desh.*	......	......	...	...	*
—— cithara, *Lam.*	......	*	*	...	*
—— crenulata, *Lam.*	......	......	*		
—— digitalina, *Lam.*	......	......	...	...	*
—— muricina, *Lam.*	......	......	*		
—— spinosa, *Lam.*	......	......	*		
Anomia lineata, *Sow.* (A. tenuistriata, *Desh.*)...................	*	*	*	*	*
Arca duplicata, *Sow.* (A. barbatula, *Lam.*?)	......	......	*	...	*

TABLE (continued).

Bracklesham Mollusca.	Sables Inférieurs, —the three lower divisions.	Lits Coquilliers and Glauconie Moyenne.	Calcaire grossier. The two lower divisions.	Calcaire grossier. The two upper divisions.	Sables Moyens.
Arca interrupta, *Lam.*	......	......	*		
—— modioliformis, *Desh.*	*	*	...	...	*
Cardita acuticosta, *Lam.*	......	......	*		
—— elegans, *Lam.*	......	*	*	*	
—— imbricata, *Lam.*	......	......	*		
—— mitis, *Lam.*?	......	*	*	...	*
—— planicosta, *Lam.*	......	*	*	...	*
Cardium hippopæum, *Desh.*	......	......	*		
—— porulosum, *Lam.*	*	*	*	*	*
—— semigranulosum, *Desh.*	......	*	*	*	*
Chama calcarata, *Lam.*	......	*	*	...	*
—— gigas, *Desh.*	......	......	*		
Clavagella coronata, *Desh.*	......	......	...	...	*
Corbula Gallica, *Lam.*	*	*	*	*	*
—— longirostra, *Desh.*	......	......	...	...	*
—— rugosa, *Lam.*	......	......	*		
—— striata, *Lam.*	......	*	*	...	*
Crassatella compressa, *Lam.*	......	......	*		
—— rostrata, *Lam.*	......	......	*	*	*
—— tenuistriata, *Desh.*	......	......	*		
Cypricardia carinata, *Desh.*	......	......	*		
—— oblonga, *Desh.*	......	......	*		
Cytherea elegans, *Lam.*	......	......	*	*	*
—— nitidula, *Lam.*	......	*	*	...	*
—— obliqua (tenuistriata, *Sow.*)	*				
—— striatula, *Desh.*	......	......	*	*	*
—— suberycinoides, *Desh.*	*	*	*	...	*
—— sulcataria, *Desh.*	......	......	*	...	*
—— semisulcata, *Lam.*	......	......	*		
Limopsis (Pectunculus, *Lam.*) granulatus, *Lam.*	......	*	*	...	*
Mactra depressa, *Desh.*	......	......	...	...	*
—— semisulcata, *Lam.*	......	*	*	...	*
Modiola lithophaga, *Desh.*	......	......	*		
Neæra (Corbula) argentea, *Desh.*		......	*		
Nucula ovata, *Desh.*?	......	......	*		
—— similis, *Sow.* (N. margaritacea, *Desh.*)	......	*	*	*	*
—— striata, *Lam.*	......	......	*		
Ostrea dorsata, *Desh.*	......	......	*	...	*
—— elegans, *Desh.*	......	......	*	...	*
—— flabellula, *Lam.*	......	*	*	*	*
—— radiosa, *Desh.*	*				
Pecten plebeius, *Lam.*	......	......	*		
—— corneus, *Sow.* (P. solea, *D.*)	......	......	*		
—— squamula, *Lam.*	......	*	*		

TABLE (continued).

Bracklesham Mollusca.	Sables Inférieurs, —the three lower divisions.	Lits Coquilliers and Glauconie Moyenne.	Calcaire grossier. The two lower divisions.	Calcaire grossier. The two upper divisions.	Sables Moyens.
Pectunculus pulvinatus, *Lam.* ...	......	*	*	*	*
Pinna margaritacea, *Lam.*	......	*	*	*	*
Solen vaginalis, *Lam.* ?	......	*	*	...	*
Solenocurtus Parisiensis, *Desh.* .	......	......	*		
Spondylus rarispina, *Desh.*	*	......	*		
Tellina donacialis, *Lam.*	*	*	*	...	*
—— lamellosa, *Desh.*	......	......	*		
—— lunulata, *Desh.*	......	......	...	...	*
—— scalaroides, *Lam.*	......	......	*	...	*
—— tenuistriata, *Desh.*	......	*	*		
Total 171	15	75	1 1	43	94
			142		

Note.—The other organic remains require a more minute comparison than has hitherto been made with French specimens. The ordinary and common forms,—such as, amongst Fishes,

Carcharodon angustidens, *Agass.*
Lamna elegans, *Agass.*
Myliobates toliapicus, *Agass.* ?
Otodus obliquus, *Agass.*

amongst Bryozoa,

Eschara Brongniarti, *M.-Edw.*
Lunulites urceolatus, *Lamx.*
Idmonea coronopus, *Defr.*

amongst Zoophytes,

Oculina raristella, *Defr.*
Siderastræa Websteri, *Bow.*
Turbinolia suleata, *Lam.*

amongst the Crustacea (Entomostraca),

Cythere striato-punctata, *Roem.*
—— costellata, *Roem.*
—— (Cythereis) horrescens, *Bosq.*
—— (Cythereis) cornuta, *Roem.*
—— (Cytherella) Munsteri, *Roem.*

and amongst the Foraminifera,

Nummulites lævigatus, *Lam.*
N. seaber, *Lam.*

have been recognized as common to the two countries, but the many other species of fishes and zoophytes, the many reptiles and crustacea, have not been sufficiently studied.

As with the shells, some of the other fossils of Bracklesham belong to other members of the French series than the Calcaire grossier,—as the *Cœlorhynchus rectus*, Ag., to the "Lits coquilliers;" and the *Nummulites variolarius*, Lam., to the "Sables moyens."

From this list it appears that of the total 171 French species at Bracklesham, 10 seem peculiar to the Lits coquilliers, 12 to the Sables moyens, and 5 to beds higher or lower even than these*. The remaining 148 species embrace a very large proportion of the characteristic forms of the Calcaire grossier. Although, considering the magnitude of the Calcaire grossier fauna, this direct numerical relationship is not very strong, yet it is far closer than with any other member of the French series. If, further, we look at the respective deposits upon independent grounds, and apply, as I did in my last paper, the test of actual progression to each within its own area, we shall find that the relative position of each deposit is maintained in a way which corroborates the synchronism suggested by a certain extent of community in the organic remains. Thus if we take 100 species of the Bracklesham Sands and Calcaire grossier respectively we shall obtain the following results, showing the agreement existing in the relation which these formations relatively hold with the other deposits above and beneath them in the two countries:—

English area.	Per centage range of Bracklesham species.	*French area.*	Per centage range of Calcaire grossier species.
Barton Clay	30†	Sables moyens	35
Bracklesham Sands	100	Calcaire grossier	100
Lower Bagshot Sands	*unfossiliferous.*	Lits coquilliers and Glauconie moyenne	29
London Clay	15	*Wanting*	......
Woolwich and Reading series	6	Sables de Bracheux	5

A large portion of the testaceous fossils common to this period in the two countries are amongst the most abundant and typical forms, as will be readily seen by reference to the foregoing list, p. 93.

On these grounds I consider we may fairly confirm the contemporaneity, in mass, of the Bracklesham Sands with the Calcaire grossier, and it only now remains to see with which portion of the Calcaire grossier these sands are most closely allied, and to search into the causes of these differences to which allusion has been made. To do this we must examine each division of the Calcaire grossier, and so study its organic remains and structure as to ascertain how far and where they harmonize with those of the Bracklesham Sands, and what indications they afford of those different conditions which prevail in this country.

§ 2. *The Calcaire Grossier—its divisions, and their organic remains compared with those of Bracklesham. The relative conditions under which these deposits were formed.*

The French geologists now generally divide the Calcaire grossier into four subdivisions, which pass one into another, but present

* These 27 species embrace some very characteristic forms of the several deposits. There are 42 peculiar to the Calcaire grossier. See list.

† The addition of the Bramshaw species would raise this proportion.

certain distinguishing features: in descending order, these divisions are—

	Feet.
4. Compact white marls, passing down into beds alternating with greenish marls and thin yellow limestones, with seams of chert; a few freshwater and brackish-water fossils sparingly distributed. Average thickness about	20
3. Thin-bedded and fissile calcareous flags and sandstones alternating with white marls and limestones; characterized in places by a profusion of æstuarine shells alternating with some freshwater forms .... about	15
2. The thick main mass of soft, light-yellow, calcareous freestone, passing in places into calcareous sands, rich in marine organic remains .... about	40
1. Variable beds of more or less calcareous green sands, sometimes concreted; often flint-pebbles at base. Marine fossils numerous only in places,—more generally absent .... about	25
Mean dimensions..............	100

In England the general sections and approximate dimensions of the Bracklesham Sands may be taken as under.

1. Section in descending order at White Cliff Bay, Isle of Wight.

	Feet.
c. Grey clay and green sands, with subordinate brown clays, yellow sands, and some small pebble-bands and lignites; vegetable impressions and shells occasionally numerous..	135
b. Thick-bedded, slightly calcareous, green sands abounding in fossils; with a central mass of grey and brown clays, with lignites	190
a. Beds of laminated grey and brownish clays, yellow sands and some green sands; comparatively few shells, numerous vegetable impressions, and a few small beds of lignite; layer of large flint-pebbles, 1 to 2 ft. thick, at base.	123
	448

2. The section of the same series at Alum Bay is as follows:—

	Feet.
Alternating thick beds of bright-coloured (yellow, white, ochreous, brown, and red) siliceous sands, tough grey brown and black clays; with subordinate foliated white, pink, and yellow clays, pebble-seams, and beds of lignite; no animal organic remains..............................	564

[For fuller details see my paper in Journ. Geol. Soc. vol. ii. pp. 252–258. The White Cliff section includes strata from 6 to 14 (excepting the upper 9 feet), and Alum Bay from 15 to 28, of the sections there given.]

To determine to what extent the French series indicates a community of origin with the English series, we must not take each only as a whole, separately and entire in itself, but rather search if there are not concurrent characters which show them to belong to disjointed parts of one body. We must follow each division of the Calcaire grossier from its most distant point to that place where it approaches nearest to the English area, and see whether the changes in dimensions, in organic remains, and in mineral characters, which take place on the same horizon in the several divisions as they range towards this country, are of such a nature that, if continued through the intervening break, they would result in inducing characters similar to those which actually obtain at Bracklesham and in the Isle of Wight.

1. To commence with the lowest or 1st division of the Calcaire grossier. This glauconite-bed is either not developed, or is in a very rudimentary state, on the boundary of the Tertiary area in Champagne; but as it trends westward it becomes more developed, and, in the central parts of the departments of the Marne and of the Aisne, attains a thickness of 6 to 10 feet, whilst nearer the department of the Oise it swells out in places to 25 and 30 feet. Of this division M. Graves gives no measured sections in this latter department, but he observes that the green sands forming the base of the Calcaire grossier expand in a direction from east to west, from the neighbourhood of Chambly to that of Gisors (Eure). M. Graves also mentions that there thin seams of foliated grey and brownish clays, with traces of lignites, are occasionally found subordinate to the sands. The fossils of this division are of very irregular occurrence, being absent or very scarce in most places, and abundant only in a few, and then chiefly in its upper beds. M. D'Archiac considers that none of the fossils are peculiar, but that those which most mark this zone are the *Turbinolia elliptica, T. Gravesii*; *Lunulites radiata*, and the *Pygorhynchus Grignonensis*;—species that are not found at Bracklesham. As these beds range westward, however, they become more fossiliferous, and in the department of the Oise M. Graves gives several localities where a considerable number of fossils are not only found in the Glauconie grossière, but some of which have their chief development in that bed. He names, amongst the most common, about seventy species from St. Felix, Ponchon, Parisifontaine, Friancourt, Hénonville, and Chaumont, of which number the following 31 are found likewise at Bracklesham:—

Beloptera belemnitoidea.

Ancillaria buccinoides.
Buccinum stromboides.
Calyptræa trochiformis.
Cassidaria carinata.
Cerithium unisulcatum.
Fusus bulbiformis.
Natica epiglottina.
—— patula.
Niso terebellata.
Ringicula ringens.
Scalaria acuta.
Turritella imbricataria.

Anomia tenuistriata.
Chama calcarata.
Corbula striata.
Cardium porulosum.
—— semigranulosum.
Crassatella compressa.
Cypricardia oblonga.
—— carinata.
Cytherea sulcataria.
Ostrea flabellula.
Spondylus rarispina.
Tellina tenuistriata.
Venericardia acuticosta.
—— planicosta.

Nummulites lævigatus.
—— scaber.
Lunulites urceolatus.
Turbinolia sulcata.

This lower green-sand division of the Calcaire grossier, thin and unimportant in the eastern portion of the Paris basin, acquires, therefore, greater development as it trends westward; whilst at the same time its organic remains become more numerous, although they never abound as in the next overlying division of this formation. Judging from the mineral character of the larger portion of the Bracklesham Sands and from the position of the *Venericardia planicosta*, *Cerithium giganteum*, and *Nummulites lævigatus* in that series, I think it probable that the expansion of this lower division of the Calcaire grossier is continued in a nearly progressive ratio as it ranges further to the north-west into the English area; and that, taken together with the lower part or even the whole of the next French division, they are here represented possibly by about the lower 250 to 300 feet of argillaceous beds and yellow and green sands of Bracklesham and White Cliff (*a* & *b* (*pars*), p. 99). For in France the *Cerithium giganteum* marks a definite and regular zone, characterizing especially the beds forming the base of the second division—those in near contact with the Glauconie grossière; the *Venericardia planicosta* is also common in that zone, but more particularly marks the uppermost beds of the Glauconie grossière; whilst the *Nummulites lævigatus* is more especially characteristic of the upper portion of the same lower division. Now in Bracklesham Bay the beds containing the *Cerithium giganteum*, and those in which the *Venericardia planicosta* so abounds, crop out in about the centre of the Bay; whilst along the shore southward towards Selsea Bill a succession of other strata, with numerous other fossils, outcrop in ascending order. In descending order, although the junction of the lower beds with the London Clay cannot here be traced, yet it is evident from the general character of the whole group that fossiliferous beds descend very low in the series. Here the Bracklesham Sands seem to be fossiliferous nearly throughout; in White Cliff Bay the lower beds are only partly fossiliferous; whilst at Alum Bay the whole series is perfectly unproductive.

On the whole a greater development, at the commencement of the Calcaire grossier period, of mineral mass, and conditions rather more favourable for life, in England than in France, are probably the causes why we find at Bracklesham so large a proportion of the shells of the Lits coquilliers relatively to the total number of French species occurring there. At the same time these early more favourable life-conditions led to the existence of a greater number of species which died out before the period of the Barton Clays, and which help, on one side, to give to the Bracklesham Sands more distinctiveness as regards that zone than the Calcaire grossier exhibits with respect to the Sables moyens.

2. The second and main division of the Calcaire grossier (the one from which it derives its name) commences near Rheims and Epernay, between which places, at Courtagnon, it is only a few feet thick. It however rapidly expands, and attains, five miles further west, at the celebrated locality of Damery, a thickness of many feet. Near Château Thierry it is 24 to 25 feet thick, and further westward, at places in the neighbourhood of Chantilly and Creil, where these beds are very largely

worked for building-stone, they are above 40 feet, and, at some spots near Clermont mentioned by M. Graves, 46 feet thick*. Proceeding still westward in the direction of Normandy this division decreases in thickness. M. Graves gives no separate measurements of it, but he states that at St. Cyr-sur-Chars the thickness of the "Groupe calcaire" (in which are included this and the next division) does not exceed 25 to 32 feet; whilst at the western escarpment of the French tertiaries the thickness of these strata varies from 6 to 16 feet only.

It is in this part of the Calcaire grossier that the rich shell-beds of Grignon, Damery, and Courtagnon occur. The fauna includes many hundred species; but again, confining ourselves to the lists of the more abundant and common species mentioned by M. Graves from Hermes, Mouchy-le-Chatel, Ully-St.-Georges, Amblainville, Parnes, Chaumont, &c., which only amount to about 120, I find that of that number the following 57 range to Bracklesham, besides the larger proportion of those enumerated above in the first or lower division. In the same way, many of the following are found in the lower division. These lists are merely intended to show those species which, according to M. Graves's numerous local details, are the most common and typical in the two zones. As it cannot however be said that any species are distinctly peculiar to the lower division, I have taken the first and second divisions together in the general list at p. 93–97.

Belosepia sepioidea.
Bifrontia bifrons.
—— disjuncta.
—— marginata.
Cancellaria costulata.
Cerithium giganteum.
Conus antediluvianus?
Cypræa inflata.
Delphinula Warnii.
Fusus longævus.
—— Noæ.
—— rugosus.
Marginella eburnea.
—— ovulata.
Melania costellata.
Murex tricarinatus.
Natica depressa.
—— sphærica.
—— Willemettii.
Parmophorus elongatus.
Pileopsis squamæformis.
Pleurotoma dentata.
—— granulata.
—— prisca.
—— transversaria.
Pyrula nexilis.
Rissoa cochlearella.
Rostellaria macroptera.
Scalaria tenuilamella.
Sigaretus canaliculatus.
Solarium canaliculatum.
—— patulum.
Tornatella sulcata.
Turritella carinifera.
—— sulcata.
—— multisulcata.
Voluta cithara.
—— muricina.
—— spinosa.

Arca interrupta.
Cardium hippopæum.
Chama gigas.
Corbula gallica.
—— rugosa.
Crassatella compressa.
Cytherea nitidula.
—— semisulcata.
—— sulcataria.
Nucula margaritacea.
—— ovata.
—— striata.
Ostrea elegans.
Pecten plebeius.
Pectunculus pulvinatus.
Solen parisiensis.
Tellina scalaroides.
Venericardia imbricata.

* M. D'Archiac mentions in one place 60 to 65 feet; p. 590.

It would appear that this division of the Calcaire grossier is most largely developed towards the centre of the Paris basin. As it trends westward into the department of the Oise, the lower beds become more mixed with green sands, and the calcareous strata become thinner. In England the calcareous beds, properly so called, are entirely wanting, being replaced by yellow and green sands, with some calcareous matter and brownish laminated clays. The abundance of many of the common French species in the middle of the Bracklesham series leaves, however, little doubt of the contemporaneity of that particular portion with the Grignon and Parnes zone. Nevertheless from the circumstance of the green-sand sediment, originally common to the two areas, having continued to prevail, but in a more muddy condition, in the English area, whilst calcareous sands formed at this period the sea-bed in the French area, those creatures which the former conditions more particularly suited,—such as the *Nummulites,* and many of the siphonate lamellibranchiates,—continued to live and abound in England after they ceased to be numerous in France. At the same time the excessive development of other Mollusca, of which the calcareous sea-bed favoured the existence in France, has no parallel in this country: comparatively few (apparently not 25 per cent.) passed at this period from the one to the other geographical area.

3. The last division passes very gradually into the next, or third, division. The distinction is more marked in the Aisne than in the Oise. In the eastward of the Paris basin this division is from 4 to 8 feet thick; it soon expands to 10 feet; and, as it approaches the Oise, attains its maximum thickness of from 25 to 30 feet. In the adjacent parts of the Oise it is from 20 to 25 feet, decreasing to a few feet in thickness as it trends further westward.

A great change here takes place in the character of the organic remains. Instead of the rich marine fauna of the underlying beds, we perceive the setting-in of freshwater conditions, and find a comparatively limited fauna. The marine shells become few and scarce; brackish-water and æstuarine shells preponderate; several species of *Cerithium* are so abundant, that these beds are sometimes called the "Calcaire à Cerites." Miliolites likewise occur in great profusion ("Calcaire à Miliolites"). Freshwater shells—*Paludina, Limnæa,* and *Planorbis*—become common in places. Some land-shells are also met with; the *Cyclostoma mumia* here occurs for the first time. The number of species enumerated by M. Graves from Mouy, Bonqueval, and Chambors amount to about forty. Of the characteristic species of this division in the Aisne and Oise, only a few occur at Bracklesham; the following are the principal:—

Cerithium calcitrapoides.
—— cristatum.
—— echidnoides.
—— semicoronatum.
Turritella fasciata.
Crassatella rostrata.
Cytherea elegans.
—— striatula.
Venericardia elegans.

There are others besides which are common throughout.

Unlike the two preceding divisions, the fossils of this one are sufficiently distinct for M. D'Archiac to give a separate list of those of the department of the Aisne*. They there amount to 96.

In France this division appears to indicate a shallowing or silting-up of the sea-bed, the occasional prevalence of fresh and brackish water, and the proximity of dry land, whereas in the English area no evidence of a like condition exists. On the contrary, the preceding conditions of sea-bed seem but little changed, and consequently, whilst we had in France a terrestrial, freshwater, and æstuarine fauna, in England a purely marine fauna still obtained. Therefore the French fauna, as a whole, is peculiar to France, and is not represented in this country; but still the synchronism of the division is indicated through the circumstance, that there are intercalated marine beds in the French division containing shells which form part of the English marine fauna of that period.

4. The fourth or uppermost division is not often of much importance. It is but little developed in the Marne, but swells out and becomes well marked in the Aisne, where, according to M. D'Archiac, it attains a thickness of nearly 60 feet. In the Oise this group does not exceed 25 feet in thickness: as it ranges westward in this department it decreases to 12 and 3 feet, and appears to thin out altogether, or nearly so, before we reach the limits of the Tertiary area. Near Paris this division is known as the "caillasses." In the Aisne, where these beds are most largely developed, they usually contain very few or no fossils; in appearance they closely resemble some of the compact white and light-green marls of the freshwater series of Montmartre. In some places the *Cyclostoma mumia* is the only shell that can be distinguished. At other places M. D'Archiac found it associated with two or three species of *Cerithium*, whilst nearer to Paris these two shells occur associated with numbers of *Paludina*, *Limnæa*, and *Planorbis*. M. C. D'Orbigny also, in describing these beds in the neighbourhood of Paris, mentions the occurrence of *Cyclostoma*, *Cyclas*, *Limnæa*, and *Paludina*, together with *Corbula*, *Venus*, and *Cerithium*†. As this bed ranges eastward, it becomes thinner, and the character of its organic remains is modified, for M. Graves does not notice the occurrence of land-shells, and mentions only one freshwater shell, the *Paludina nana*, whereas he gives a list of nine brackish-water species almost all common to the underlying beds. Of these only one species, the *Crassatella rostrata*, occurs at Bracklesham.

The upper two divisions of the Calcaire grossier may possibly correspond with the upper 130 to 200 feet of the Bracklesham and White Cliff Bay beds. (*c*. and part of *b*. ?)

It thus appears that the upper Calcaire grossier is in the eastern part of the French basin almost entirely freshwater; that these conditions are less marked in the central area, are much modified in the eastern, and do not exist at all in England, where marine forms continue up to the very top of the Bracklesham series. Of the ten fossils which M. Graves quotes from these beds, two are species which are not found in the other divisions of the Calcaire grossier, but

* Mém. Soc. Géol. de France, vol. v. p. 236.

† Tab. syn. But few species are named.

are met with in the overlying Sables moyens. This setting-in of newer forms appears, however, from a recent discovery of Mr. Edwards, to be much more marked in this country at a spot near Bramshaw, between Lyndhurst and Salisbury. The superposition of the bed is not shown; but, judging from its place of outcrop and its fossils, I should place it at the top of the Bracklesham series. From this bed 103 species of Mollusca have been obtained, and of this number 45 are Barton species—a much larger proportion (in the ratio of 43 to 30) than exists at Bracklesham. As in the lower Bracklesham zone, in which we have a larger preponderance than in France of the fossils of the next underlying series, so in this upper one we have a nearer agreement with the fauna of the overlying series; for in France, taking the total of the Calcaire grossier species, 35 per cent. range upwards, whilst at Bramshaw the proportion passing upwards is 43 per cent. Not only is the proportion of Barton species so much larger in this bed, but there are also found in it several species which in France do not appear until the period of the Sables moyens. In England, on the contrary, some of these latter species* have not been found in the Barton Clays, presenting us therefore with the anomaly of species characterizing the upper zone of one formation in England, absent in the synchronous zone in France, migrating to and flourishing in that latter area in the next overlying series, whilst in the contemporaneous English beds they are wanting. This in fact is a phænomenon apparently common throughout the Eocene series, and should render us very careful in drawing any conclusions from observations upon a limited number of organic remains.

Although the four subdivisions of the Calcaire grossier are generally maintained and sufficiently well marked, still it must not be supposed that they are independent. On the contrary, it is often difficult to draw a line of separation between them. Not only do they pass one into another by lithological characters, but also by organic remains; yet on the whole these latter, taken in conjunction with the mineral mass, are sufficient to give to each subdivision a peculiar type and character of its own, not only over the whole French area, but in some instances shadowing their features in adjacent Tertiary areas of the same age.

The cause of the great actual difference in the French and English series arises probably from the more marine conditions maintained in this country throughout the Calcaire grossier period—conditions resulting, I believe, from a more constant and rapid subsidence of the English area, keeping a moderately deep sea, and serving to receive comparatively thick deposits during the whole of this period; whereas the movement extending only in part and in a very minor degree, if at all in many places, over the French area, we there find evidence of the sea being silted up, shut out, and replaced by freshwater lakes and lagoons. In all this inquiry it is to be noticed that, although the species in the two countries differ considerably, yet on the whole the same genera are common in both: not only so, but the species are generally developed in somewhat the same ratio

* As the *Cerithium Bouei* and *Voluta mutata*.

with regard to the relative richness of each fauna; and also, whilst almost each genus presents some species in common, the other species are constantly representative forms. The principal exceptions are—in the instance of *Turbo, Trochus, Pileopsis,* and *Delphinula,* of each of which there are but 3 species in England, whereas in France they are exceedingly numerous;—the absence here of *Venus, Donax,* and *Corbis*;—and the presence of a larger proportion of reptiles and fishes.

§ 3. *The Belgian equivalent of the Calcaire grossier and Bracklesham Sands—the Bruxellian System.*

Owing to the want of sections in Belgium it is very difficult to follow the succession of the strata. The zone of the *Nummulites planulatus* appears to be well marked, and to correspond with the Lits coquilliers and associated sands in France, and with the Lower Bagshot Sands in England.

Above this there is, near Brussels, a stratum of siliceous sands about 40 feet thick, considered to form the lower part of the Bruxellian System. To this succeed, in ascending order, 30 to 40 feet of sands with sandstone-concretions; then a more calcareous greenish sand, 10 feet thick, containing many fossils, and overlaid by 2 feet of sands with *Nummulites lævigatus,* and 20 feet of fossiliferous sands with calcareous concretions,—making a total thickness of about 100 feet. The fossils are confined chiefly to the upper portion of this formation; and the strata decrease in importance as they range northward.

This series of strata seems to represent exactly the Calcaire grossier of France and the Bracklesham Sands of England. It contains a large proportion of fossils common to both countries, of which the most characteristic species are—

Acteon sulcatus, *Lam.*
Arca barbatula, *Lam.*
Cardita decussata, *Lam.*
Cardium porulosum, *Lam.*
Cassidaria carinata, *Lam.*
Conus deperditus, *Brug.*
Corbula gallica, *Lam.*
—— rugosa, *Lam.*
Cypræa inflata, *Lam.*
Fusus Noæ, *Lam.*
Lucina sulcata, *Lam.*
—— gibbosula, *Lam.*
Mactra semisulcata, *Lam.*
Melania marginata, *Lam.*
Natica epiglottina, *Lam.*
—— labellata, *Lam.*
—— patula, *Desh.*
Nummulites lævigatus, *Lam.*
Ostrea flabellula, *Lam.*
Pecten plebeius, *Lam.*
Rostellaria ampla, *Brand.*
Solarium patulum, *Lam.*
—— spiratum, *Lam.*
Tellina tenuistriata, *Desh.*
Turritella terebellata, *Lam.*
Venericardia planicosta, *Lam.*
Voluta cithara, *Lam.*

Both Sir C. Lyell and M. Omalius D'Halloy give lists of the fossils from these beds. The one enumerates 67 species, and the other 92*. Of these, 82 species are peculiar to the Brussels beds, and

* As M. O. D'Halloy gives no sections, I cannot feel sure that his division corresponds exactly with that of Sir Charles Lyell.

31 range up into the Laeken beds. The foreign distribution of the species is approximately as under:—

Total number of species of the Bruxellian beds.	Common in England to the			Common in France to the		
	Lond. Clay.	Brackl. Sands.	Barton Clay.	Lits Coq.	Calc. gross.	Sables moyens.
113	15	49	32	43	73	56

[*Note.*—In the foregoing calculations I have not included the upper beds at Cassel grouped by Sir C. Lyell with the Sables moyens, but which I am inclined to place with the Calcaire grossier. See p. 116.]

§ 4. *The Barton Clays, Sables Moyens or Grès de Beauchamp, and Laekenian System.*

At the time that I published my paper on the Isle of Wight Tertiaries there existed no complete list of the fossils of the Sables moyens. The short list of M. D'Archiac, in his 'Geology of the Aisne,' showed about an equal number of Bracklesham and Barton species*. The Barton species had always been referred by both French and English geologists to the Calcaire grossier, and, although I felt some doubt about this correlation, still, in the absence of data to test its accuracy more fully, I saw no sufficient cause to disturb the prevailing view. I therefore placed the Barton Clay on the level of the upper Calcaire grossier—a position to which I the more readily assigned it as the Bracklesham series nowhere showed traces of the freshwater conditions prevailing at the top of the Calcaire grossier, but which do commence immediately over the Barton Clays, with many of the same fossils, such as *Cyclostoma mumia, Planorbis rotundatus, Limnæa longiscata*, &c.

Since that period M. Graves has published full lists† of the Sables moyens fossils of the Oise, and has alluded to the circumstance of finding amongst them several Barton species. M. Dumont and M. Hébert, after visiting Barton, also expressed their belief that those clays were of the age of the Sables moyens, as many of the common shells of that French period were found there. Such being the opinion which the general character of the fossils of this deposit led these eminent geologists to form, I was necessarily led to reconsider the question; and this further review of the physical conditions, and examination of the organic remains of the French and English series, induce me to adopt the same conclusions; the reasons for so doing I purpose now to give in greater detail.

In lithological characters the difference between the Sables moyens and the Barton Clay is very marked; the former consisting essentially of a mass of siliceous sands, occasionally passing into hard siliceous sandstone, from 80 to 120 feet thick; and the latter (in the limited sense usually taken) of compact dark-brown and grey clays 280 to 350 feet thick, with bands of large septaria. In looking, however, more minutely into the structure of these deposits we find that there are with them, as with the Calcaire grossier and Brackle-

* Mém. Soc. Géol. de France, vol. v. p. 227.

† *Op. cit.* p. 480.

sham beds, certain elements in common which seem to connect the two deposits, by showing that, although no doubt derived from the waste of two different lands, yet that they probably were deposited in the same sea, as the sediments pass partially into one and the other area, and have been to a certain extent subjected to the same disturbing causes. Taking this formation in a horizontal plane, the changes which it exhibits as it ranges from east to west in the Paris area are, in a measure, progressive (although not in the same ratio) and in accordance with the changed conditions apparent in the Hampshire area.

I must, in the first place, observe, that in the Barton series I would now include the siliceous sands at the base of Headon Hill and at the top of Barton Cliff. For, although they contain no organic remains at those spots, casts of marine shells, apparently of the same species as those in the underlying clay, occur in considerable numbers in parts of the sands occupying the same position at White Cliff Bay; whilst at Barton, as the deposit ranges eastward towards Hordwell Cliff, these sands alternate with fossiliferous grey clays, and form with them passage-beds between the purely marine and compact Barton Clay and the freshwater beds nearer Milford. I would therefore give, as constituting the Barton series at the three places where it can be distinctly recognized and measured, the following general sections. They will serve to show the rapid variations to which this series is subject even within this limited area,—the distance from Barton to Alum Bay being six miles, and from Alum Bay to White Cliff Bay twenty-one miles.

1. *General Section of the cliff from High Cliff to Barton, on the coast of Hampshire* *.

			Feet.
b.	Yellow and white siliceous sands, averages	about	15
	Grey sandy clay—with *Avicula, Cardium, Oliva,* &c.—divided by a wedge-shaped bed of sand............	about	30
	Yellow siliceous sands	,,	30
	Grey clayey sands—*Chama, Pectunculus, Nucula,* &c.	,,	20
a.	Mass of compact bluish-grey clay with septaria; shells dispersed throughout—*Voluta, Fusus, Murex, Pleurotoma, Cardium, Tellina, Corbula,* &c.	about	150
	Grey clay, with seams of yellow sand and shells ...	,,	20
	Grey sandy clay—*Echini, Cassidaria,* &c.	,,	50
	Mixed clay and green sand, impressions of shells ...	,,	14
	Bed of flint-pebbles in sand,—size moderate.........	,,	1
			330

Or, resolving the mass roughly into its elements, we find it here consists of—

Siliceous sands, about............ 45 feet.
Clays .... 285 ,,

* For fuller details of this section, see Dr. Wright's paper in the Proc. Cotteswold Naturalists' Club, vol. i. p. 129–133, 1853.

2. *Section of the cliff at Alum Bay, Isle of Wight.*

		Feet.
b.	Pure white siliceous sands, with yellow clay at base	100?
a.	Dark-grey clay, with septaria and few shells	95
	Dark clayey green-sand, with few fossils....................	65
	Brown and grey clay with *Nummulites*, passing into clay mixed with green-sand; layers of septaria;—shells numerous	119
	Basement-bed of flint-pebbles, very large	1
		380

Or of—

Siliceous sands	100 feet.
Clays	280 ,,

3. *Section of the cliff at White Cliff Bay, Isle of Wight**.

			Feet.
b.	Yellow siliceous sands: casts of marine shells in some of the beds	about	202
a.	Laminated brown clay and greenish sand	,,	37
	Yellow siliceous sand	,,	44
	Brown and grey clay, with fossils	,,	157
	Band of grey siliceous sandstone	,,	5
	Light-grey and brown clay—*Corbula, Nummulites.*	,,	32
	Striped ochraceous and white sands	,,	12
	Largish flint-pebbles and ironsand (basement-bed)		1
			490

Or of—

Siliceous sands	263 feet.
Clays	227 ,,

The above particulars do not give the full details of all the beds, but they give the general and prominent mineral masses. In the Barton section the top sands vary in thickness from 10 to 15 feet; at Beacon-Bunny the underlying clay measures about 20 feet †, and thickens westward to about 40 feet, including the subordinate bed of siliceous sand. Occasional seams of flint-pebbles occur through the lower beds "*a*" in all three places, but they are always small and unimportant, and mark no line of break as the larger layer of pebbles at the base of the series does. Green sand, in small quantities, is mixed with almost all the clays; and all the parts of "*a*" may be considered as parts of one mass. These beds immediately overlie the sands of the Bracklesham series. The sands "*b*" are in each case overlied by the green freshwater clays; but at the Barton section a thin bed of sand, full of æstuarine shells, is interposed between the Barton sands and the freshwater clays.

* See my paper in Journ. Geol. Soc. vol. ii. pp. 253–257. These sections differ from my former ones by some additional details which I have since been able to observe. No. 2 section corresponds with strata Nos. 29 and 30; and No. 3 section with strata No. 14 (part of) to 20 of that paper.

† These are known as the Beacon-Bunny beds, and contain a peculiar group of brackish-water shells.

The palpable features in these sections are the preponderance of clays, the decreased importance of these clays as they range eastward and southward, and the increasing importance of the quartzose sands in the same direction. If now we turn our attention to the extreme range eastward in France of the "Sables Moyens," we shall find no apparent relation with the English series. In the neighbourhood of Rheims they consist of siliceous sands a few feet thick, and with but few fossils: as they trend towards Paris they gradually become thicker, and at La Ferté-sous-Jouarre they present the following section (D'Archiac), underlying 195 feet of the green marls and freshwater limestones of the gypseous series:—

	Ft.	in.
Calcareous freestone, with marine remains	5	0
White shelly sand (siliceous?)	19	6
Beds of sandstone	6	6
	31	0

and overlying 114 feet of "Calcaire grossier," under which are 107 feet of "Sables Inférieurs*." Further westward the sands rapidly expand; and, near Villers-Cotterets, attain an exceptional thickness of 175 feet, consisting throughout of siliceous sands and sandstones with few or no fossils.

M. D'Archiac gives as the principal fossils in this eastern part of the Paris basin (the department of the Aisne)—*Astræa stylophora, Nummulites variolarius, Corbula angulata, Cyrena deperdita, Venus solida, Paludina globulus, Cerithium thiara, Fusus minax, Voluta labrella,* and *Portunus Hericarti.*

Immediately west of this spot a marked change takes place: the thickness of the series decreases again to 80 or 90 feet, and certain divisions and physical features, which become still more prominent in the Oise, set in. In places in the vicinity of Beaumont and Auvers there occurs at the base of the "Sables Moyens," in a bed of white sand with flint-pebbles, numerous fossils derived from older tertiary beds, almost all broken and much worn. Above this there is often a variable bed of laminated sandy green clay without fossils. This is overlied by 30 to 40 feet of white sand, the upper part consolidated into a siliceous sandstone. These are succeeded at Auvers by the celebrated shelly and conglomerate beds of that locality. In 1854 this section presented in descending order the following succession of strata under the surface-soil:—

Section of Stone-pit at Auvers, Oise.

	Feet.
Broken sandstone and sands, with a few shells	3
Yellow sands full of shells, and with small pebbles; laminæ with a subdip eastward	3
White sandstone: white sand and shells	1
Light-coloured sand (sometimes the lower part stained fer-	

* Hist. des Prog. vol. ii. p. 571.

	Feet.
ruginous) with pebbles of flint, of sandstone, and of Calcaire grossier, the latter often pierced by boring shells; laminæ with a subdip westward; organic remains numerous	5
Light yellow soft sandstone	2
White sand and shells	1
Light-coloured saccharoid sandstone, with a few seams of shells and some pebbles: base not exposed	20
	35

At Hadancourt near Chaumont the "Sables Moyens" appear to be, as well as I could judge from a well-section, about 70 feet thick, but I could not there ascertain its subdivisions*. A cutting on the side of a road above Triel gave me in 1855 the following section:—

Road-side Section, Triel, Seine et Oise.

	Feet.	
Thick-bedded freshwater limestones.		Base of Calcaire lacustre?
Laminated freshwater marl and limestone?	3	Sables Moyens. These beds seem to belong to the upper part of this deposit, and that the lower beds are wanting.
Light-green marly sands, with numerous small shells in patches at top; fewer in the lower part	8	
Shelly sandstone	3	
Unfossiliferous clayey sands	4	
Hard tabular sandstone, no shells	3	
Light-yellow and greenish sandy clay, with few or no fossils	3	
	24	
White marls and freshwater limestones, with a subordinate bed of sand	9	Upper part of the Calcaire grossier.

The general section of the "Sables Moyens," as given by M. Chas. D'Orbigny in his *Tableau synoptique*, and including more especially the district within 30 to 40 miles of Paris, is as under:—

	Ft.	in.
1. Thin beds of greenish marl and brown clay, with an intercalated bed of shelly greenish sand—*Avicula fragilis, Cerithium mutabile, Fusus subcarinatus* ...	6	6
2. Calcareous sandstone, very shelly, sometimes passing down into a calcareous and sandy freestone—*Cerithium lapidum, Natica mutabilis, Melania hordeacea, Cytherea elegans, Portunus Hericarti*, &c.	10	0
3. Sand full of fossils, many rolled—*Astræa stylophora, Nummulites variolarius, Cyrena deperdita, Cardium obliquum, Voluta labrella, Limnæa*	6	6
4. Quartzose sands and sandstone in places mixed with green sand, and containing masses of fossil wood, and sometimes a considerable number of shells—		

* Another well at Cuvergnon, mentioned by M. Graves (p. 445), gives a thickness of 110 feet to the "Sables Moyens."

	Ft.	in.
Corbula gallica, Lucina saxorum, Cerithium tuberculosum, C. mutabile, C. tricarinatum, Cyclostoma mumia, Limnæa longiscata, &c.: average	50	0
5. Greenish-grey sandy marls, full of marine shells	1	6
6. Green marl	3	0
7. Conglomerate bed—*Fistularia*	0	6
	78	0

M. Graves gives no exact measurement of the Sables moyens in the Oise, but he states that they may there be distinctly divided, commencing at the top, into—

1. Alternating beds of sand and sandstone, sometimes calcareous, marly, and pebbly*; numerous organic remains, and occasional subordinate thin beds of green marl and limestones with freshwater shells†.
2. A central thick mass of quartzose sands and sandstones, without organic remains, excepting pieces of wood.
3. An argillaceous brownish sandy marl and sands, rich in organic remains, containing, as subordinate and occasional beds at the base of the series,—1. Green and brown marls. 2. Conglomerate of worn flints, flint-pebbles, pebbles of the Calcaire grossier, and of the sandstone of the "Sables Inférieurs."

In the upper beds the principal characteristic fossils are—*Trochus monilifer, Solarium trochiforme, Cerithium Cordieri, C. thiarella, C. Roysii, C. pleurotomoides, Modiola seminuda, Chama papyracea, Avicula fragilis, Paludina nana, Cyrena deperdita, Oliva Laumontiana, Ostrea cubitus,* and the *Portunus Hericarti* and *Lichenopora crispa*; and in the lower beds—*Cerithium trochiforme, C. tuberculosum, Conus scabriusculus, Voluta Branderi, V. digitalina, Ampullaria ponderosa, Chama turgidula, Venericardia cor-avium, Corbula umbonella, Sanguinolaria Lamarckii, Ostrea arenaria,* and *Nummulites variolarius.*

A peculiar feature of the fossils of the upper division is their usually small size. In some of the subordinate masses of hard grey concretionary sandstone I have found freshwater shells (*Limnæa*) and flint-pebbles, in some number‡. It is remarkable in places for the abundance of a species of Crab—the *Portunus Hericarti,* Desm.

In the central beds there are found pieces of silicified wood often many feet in length. The blocks of sandstone also sometimes show rootlet-like traversings, as well as vegetable impressions on the broken surfaces. These sandstones, generally void even of such organic remains, are largely worked for paving-stones.

The fossils of the lower division are often stained yellow, and the shells are somewhat thicker than those of the Calcaire grossier. In the conglomerate at the base of this division remains of the older

* *Op. cit.* p. 452. † *Ibid.* p. 456.

‡ At Nauteuil-le-Haudouin the top sandstones alternate with beds of freshwater limestone.—*Op. cit.* p. 435.

Tertiary strata are common. The large and thick *Cucullæa crassatina* of the Bracheux Sands, rolled and worn, is met with,—so also the *Cyrena cuneiformis* of the Argile Plastique, and the *Cerithium giganteum* and *Nummulites lævigatus* of the Calcaire grossier*.

I cannot quite reconcile the account given by M. Graves of the pebble-bed, for he speaks of it as though there were only one, and that one at or near the base of the series; whereas the bed above described at Auvers, which also contains fossils of the older strata and pebbles of Calcaire grossier pierced by boring Molluscs, is evidently high up in the "Sables Moyens." The want of diagrams in M. Graves's work renders it difficult to reconcile what may possibly be only an apparent anomaly. According to M. Chas. D'Orbigny †, there are two conglomerate- or pebble-beds, one at the base of the series, and the other at the base of the upper division; and in this view, as far as my own personal observation goes, I am disposed to agree.

The pebble-bed of M. Graves attains its greatest importance in the western part of the Oise. It there occasionally forms thick accumulations somewhat resembling those of Blackheath. This pebbly condition of the deposit constitutes an essential feature in this area.

With respect to the organic remains, I have examined as to the species quoted by M. Deshayes and M. D'Archiac from the Sables moyens, and more particularly the lists of M. Graves, which are not only the most complete, but also give the fauna of that part of the French Sables moyens area which approaches nearest to England. I have, as usual, confined myself on all points of comparison to the Mollusca exclusively, as they have been in both countries more fully and equally worked out than the other organic remains. The number of known species enumerated by M. Graves from the Sables moyens of the Oise is 377; from Barton we have 252. The Barton species are thus distributed:—

Total Barton species.	England.		
	Common to the London Clay.	Common to the Bracklesham Sands.	Species peculiar to Barton.
252	36	103	140
	Common in France to the		
	Lits Coquilliers.	Calcaire Grossier.	Sables Moyens.
	47	82	77

* *Op. cit.* p. 447. M. Graves does not, however, consider that this old pebble-bed is quite at the base of the "Sables Moyens." He thinks that the accumulation of these sands commenced tranquilly, and was interrupted after some time by a period of disturbance, after which the formation resumed its regular course (p. 448).

† Tableau Synoptique.

From this it would at first sight appear that these Barton beds had more affinity with the Calcaire grossier than with the Sables moyens, as the actual number of species common to the former is greater than to the latter; but it must be remembered that the number of described Caleaire grossier shells is nearly double that of the Sables moyens, consequently the relative proportion of common species is greater with the latter beds, although the actual number of Calcaire grossier forms is larger. Taking the number of Calcaire grossier Testacea to be 651 and of the Sables moyens 377, the relative per-centage proportion of the species of each of these groups occurring at Barton is—

Calcaire grossier 12·4; Sables moyens 21; or as 4 : 7 nearly.

At the same time the question is rendered more involved by the circumstance that there are as many as 18 Calcaire grossier species which do not appear in the Bracklesham Sands, but which are found in the Barton Clays*; and in the same way there are several Bracklesham species which I do not find quoted from the Calcaire grossier, but are found in the Sables moyens†. This shows how necessary it is to take the entire group of organic remains, for, assuming the species to be correctly determined, it seems impossible in nearly related divisions of this description to found any sufficient argument respecting the synchronism of the strata upon the occurrence of any one or even several common species, although they may be ordinary forms in one particular area.

It is also to be observed that of the seven *Corals* described by M. Milne-Edwards from Barton he has mentioned only one French species, and that one from the Calcaire grossier, although the Sables moyens are characterized by a considerable number of this class of fossils. Further, one only of the six Barton *Annelids*, and none of the eight *Echinoderms* have yet been recognized in the Sables moyens. Of the few scarce Fishes, Reptiles, and larger Crustacea which occur in both deposits, none have at the present time been determined to be common to the two. All these, however, require a more careful and extended comparison than has hitherto been made.

The same with the Foraminifera: of the several species described in the Sables moyens, only one, but that however a very characteristic one, has yet been noted in the Barton Clay, viz. the *Nummulites variolarius*. There are many other species, but the genera only have yet been determined.

The microscopic Crustacea have been determined by Mr. Rupert Jones, to whom I am indebted for a list which shows that out of the 13 Barton species, there are 6 which are found in the Calcaire grossier, and only 5 in the Sables moyens.

* Including the following species:—*Bulla coronata, Cerithium cinctum, Fasciolaria funiculosa, Murex crispus, M. tripteroides, Strombus Bartonensis, Crassatella sulcata, Lucina gigantea, Neæra cochlearella, Vulsella deperdita*, &c.

† Including the *Natica ponderosa, N. lineolata, Orbis patellatus, Voluta Branderi, Mactra depressa*, and *Tellina lunulata*.

Both deposits are marked by a paucity of Cephalopoda. Not a single species of *Nautilus* has yet been quoted from either country. Freshwater shells are very scarce in the Barton Clay proper, whereas the Sables moyens, especially the upper beds, contain a considerable number, including several species of *Limnæa* and *Cyclostoma*, genera not occurring at Barton. In both deposits there is a profusion of molluscs of the genera *Fusus, Pleurotoma, Lucina,* and *Corbula.*

Other evidence therefore of the contemporaneity of these beds is required. First, if we look to see what species there are in common, we shall find that, although not numerous, they are well marked and characteristic. The following shells are common and special to this zone both in France and England:—

Cerithium mutabile, *Lam.*
Chama squamosa, *Brand.*
Conus scabriusculus, *Sow.*
Lucina ambigua, *Defr.*
—— Menardi, *Desh.*
Modiola seminuda, *Desh.*
Oliva Branderi, *Sow.*
Pectunculus deletus, *Brand.*
Trochus monilifer, *Lam.*
—— patellatus, *Desh.*
Venericardia cor-avium, *Lam.*
Voluta ambigua, *Brand.*
—— athleta, *Sow.*
—— depauperata, *Sow.*

and I think, probably,—

Volvaria acutiuscula, *Sow.*?
Corbula umbonella, *Desh.*

Whilst the following species, although extending into other beds in England, are peculiar to the Sables moyens in France:—

Cancellaria evulsa, *Brand.*?
Clavagella coronata, *Desh.*
Murex asper, *Brand.*
Voluta digitalina, *Lam.*

If, further, we measure the distinctiveness of each fauna in its own area, we shall find that the two deposits are distinguished by a nearly like amount of difference. Thus the relative proportion of all the species ranging from the lower to the upper deposits in each country respectively is in the following ratio:—

Barton..........	30	Sables moyens....	35
Bracklesham	100	Calcaire grossier..	100

Whilst if we take the per-centage in descending order, we have:

Barton..........	100	Sables moyens....	100
Bracklesham	45	Calcaire grossier..	50

These are only submitted as approximate numbers *.

Belgium.—Above the Bruxellian System in Belgium there are 20 to 30 feet or more of green and yellow sands occasionally pebbly at base. M. Dumont has termed these the Laekenian System, and considers them, as does Sir C. Lyell, to be the equivalent of the Barton Clay. There appears a difficulty connected with such a correlation, inasmuch as the proportions of Barton and Bracklesham

* The amount of difference between the two French deposits was first distinctly noticed by M. D'Archiac in 1837 (Bull. Soc. Géol.). Out of 320 species of "Sables moyens" shells, he estimated that 166 ranged from strata lower in the Eocene series, and that 154 were peculiar to that formation.

shells appear so equal in this and the underlying formation; but still the number of Calcaire grossier species is very much less*. If we treat this question as we have done the previous one respecting Barton, and take the proportion of species common in the two successive periods in each area, we obtain the following result:—

Sir C. Lyell gives 58 species of Molluscs from the Laeken beds, and M. D'Halloy 84.

Total number of species of the Laeken beds.	Common in England to the			Common in France to the		
	Lond. clay.	Brack-lesham.	Barton clay.	Lits coq.	Calc. gross.	Sables moyens.
95	8	36	31	28	45	32

If we consider the actual magnitude of each fauna in the several typical provinces, and take the number of Molluscs in the Calcaire grossier, Bracklesham Sands, Sables moyens, and Barton Clay to be respectively 651, 368, 377, and 252, then of each of these faunas there are in the Laeken beds the following per-centage:—

Bracklesham	9·5	Barton	12·	or as 3 : 4 nearly.
Calcaire grossier	6·7	Sables moyens	8·5	or as 3 : 4 nearly.

showing a difference considerably less than that which is exhibited by the equivalent deposits in the French and English areas, though still somewhat in favour of affinities between the Laeken beds and the Sables moyens.

If we apply the per-centage test to note the actual difference between the two deposits in the Belgian area, we find also some anomaly; for their distinctiveness is greater than between the equivalent French and English beds. Thus the above-named lists show only 29 species common to the Brussels and Laeken beds. This gives the proportion of shells ranging from the lower to the upper deposits as—

Laeken beds	27
Brussels beds........................	100

a proportion I cannot reconcile with the other facts. The Barton

* As I cannot help feeling some doubt in the correlation suggested by Sir C. Lyell of the upper beds at Cassel (*f* and *g*, figs. 4 and 5, *op. cit.*) with the Barton Clay and Sables moyens, I have excluded the upper Cassel list from the following calculations, and confined myself to his Brussels and lower Cassel list. Although it is true that the *Nummulites variolarius* occurs in the Cassel beds, and is considered peculiar to the Sables moyens, yet it is not limited to that zone in England, as it is apparently found with *N. lævigatus* in the Bracklesham Sands of the Isle of Wight (Q. J. G. S. vol. viii. p. 334, *note*). We have also to note the occurrence of the *Cerithium giganteum*, which is found associated with the *N. variolarius* at Cassel, and which fossil both in France and England is confined to the Calcaire grossier zone. Further, with the exception of the *Natica ambulacrum*, *Cardium turgidum*, and *Pecten reconditus*, all the other foreign species belong to the Calcaire grossier and Bracklesham Sands; the larger number in fact appearing to me to be the fossils of that zone, to which group I should be inclined to refer these Cassel beds. I will not, however, say that the Sables moyens are altogether wanting at Cassel. Some of the higher beds may prove to be of that age. My own examination of that hill has not been sufficiently detailed to speak from personal knowledge.

clays also exhibit 31 species in common with the Laeken beds, and 32 with the Brussels bed.

There are, however, in the Laeken beds some of the characteristic shells of the upper French and English zone, as the

Avicula fragilis, *Defr.*
Bulla constricta, *Sow.*
—— Sowerbyi, *Nyst.*
Cardium turgidum, *Brand.*
Corbula umbonella, *Desh.*
—— pisum, *Sow.*
Crassatella plicata, *Sow.*
Cypricardia pectinifera, *Sow.*
Lucina ambigua, *Defr.*
—— saxorum, *Lam.*
Ostrea gigantea, *Brand.*
Turritella brevis, *Sow.*
Venerupis striatula, *Desh.*

The *Nummulites variolarius*, which in France characterizes the zone of the Sables moyens, appears, in Belgium, to have lived in the upper beds of the Bruxellian System, as there is some reason to believe that it did in the upper part of the Bracklesham series in England. At the same time, if the Belgian divisions are rightly drawn, many species peculiar to the underlying zone in France and England appear in Belgium to have reached on to the Laeken period. Amongst them especially the Belgian geologists give the *Cerithium giganteum*, *Scalaria crispa*, *Cardita imbricata*, *Crassatella compressa*, *Pecten imbricatus*, and some others. The paucity of *Pleurotomæ* and *Cerithia* in both divisions in the Belgian area, contrasts strongly with their abundance in France and England. On the whole, the affinities of the Laeken beds are rather greater with the Barton clays and the Sables moyens than with the other zones; still I consider the question an open one. It is possible that the Laeken beds may be the marine equivalents of the upper Calcaire grossier, like the Bramshaw beds; or it is possible that the apparent confusion may be caused by an intermixture of the fossils of some of the lower beds,—the equivalents of the Lits Coquilliers, or of those of the upper divisions.

The following is a list of the organic remains found in the Barton Clay. Three sets of columns are added,—the first showing the range of the Barton species in the other underlying English Tertiaries, the second in the contemporaneous and underlying French Tertiaries, and the third in the contemporaneous and next underlying Belgian series. For the Paris area my authorities are M. Deshayes, M. Graves, and M. D'Archiac, and my own collection; and for the Belgian area Sir Charles Lyell and M. Omalius D'Halloy *.

* Mr. Edwards and Mr. Morris have kindly examined and corrected this list; and to Mr. Rupert Jones I am indebted for the addition of the various species of microscopic Crustacea. Feb. 1857.

Table of Barton Fossils.

Mollusca of the Barton Clay.	Range of species. London area. A. Lower Sands.	B. London Clay.	D. Bracklesham Sands.	Paris area. A. Sables de Bracheux.	C. Lits Coquilliers.	D. Calcaire grossier.	E. Sables Moyens.	Belgian area. D. Système Bruxellien.	E. Système Lackenien.
GASTEROPODA.									
Acteon (Tornatella, *Lam.*) crenatus, *Sow.* var. elongatus, *Sow.*	......	......	*						
—— fenestratus, *Charlesw.*	......	......	*						
—— inflatus, *Fér.*	......	......	*	......	......	* ?	*		
—— (Bulla, *Brand.*) simulatus, *Sow.*	......	*	*	......	......	......	......	......	*
Adeorbis elegans, *Charlesw.*									
Ancillaria buccinoides, *Lam.* (A. subulata, *Sow.*)	......	......	*	......	*	*	*		
—— canalifera, *Lam.* (A. turritella, *Sow.*)	......	......	*	......	*	*	*		
Buccinum (Daphnella) junceum, *Sow.*	*	*	*						
—— lavatum, *Sow.* (B. desertum, *Br.*)									
Bullæa									
Bulla attenuata, *S.* (var. semistriata, *D.*)	......	*	*	......	*	......	......	......	*
—— conulus, *Desh.* ?	......	......	......	......	......	*			
—— coronata, *Lam.*	......	......	......	......	*	*			
—— Defrancii, *Sow.* (B. lignaria, *Desh.*)	......	......	*	......	*	......	......	......	*
—— constricta, *Sow.*	......	......	......	......	......	......	......	......	*
—— elliptica, *Sow.*	......	......	*						
—— extensa, *Sow.*	......	......	*						
—— filosa, *Sow.* (striatella, *Desh.*)	......	......	......	......	......	*	*		
—— incisa, *Edw.*									
—— lanceolata, *Sow.*	......	......	*						
—— ovulata, *Lam.*	......	......	......	......	......	*	*		
—— Sowerbyi, *Nyst*	......	......	......	......	......	......	......	......	*
Calyptræa obliqua, *Sow.*									
—— trochiformis, *Lam.*	*	*	*	*	*	*	*	*	*
Cancellaria canaliculata, *Edw.*									
—— crenulata, *Desh.*, var.	......	......	*	......	*				
—— evulsa, *Brand.*	......	......	*	......	......	......	*		
—— microstoma, *Charlesw.*									
—— quadrata, *Sow.*	......	* ?	*						
—— umbilicata, *Edw.*	......	......	*						
Cassidaria (Buccinum) ambigua, *Brand.*	......	......	*						
—— carinata, *Lam.* (B. nodosum, *Brand.*)	......	*	*	......	*	*	*	*	
Cerithium (Murex, *Br.*) angulatum, *Br.* (C. hexagonum, *Lam.*; pyramidale, *Sow.*)	......	......	*	......	*	*			
—— cinctum, *Lam.*	......	......	......	......	......	*			
—— concinnum, *Charl.* (C. lima, *Desh.*)	......	*	*						
—— emarginatum, *Lam.*	......	......	......	......	......	*			
—— filosum, *Charlesw.*									

TABLE (*continued*).

Mollusca of the Barton Clay.	Range of species.								
	London area.			Paris area.				Belgian area.	
	A. Lower Sands.	B. London Clay.	D. Bracklesham Sands.	A. Sables de Bracheux.	C. Lits Coquilliers.	D. Calcaire grossier.	E. Sables Moyens.	D. Système Bruxellien.	E. Système Laekenien.
Cerithium geminatum, *Sow.* ?									
—— mutabile, *Lam.*	......	......	......	......	......	......	*		
—— rigidum, *Brand.*									
Chemnitzia rudis, *Charlesw.*									
Conus Dormitor, *Sow.*									
—— lineatus, *Brand.* (C. corculum, *Sow.*)	......	......	* ?						
—— scabriculus, *Sow.*	......	......	......	......	......	......	*		
Cuma Charlesworthi, *Edw.*									
Cypræa Bartonensis, *Edw.*									
—— platystoma, *Edw.*									
Dentalium acuminatum, *S.* (D. entale, *B.*)									
—— striatum, *S.* (D. acuticosta, *Desh.*?)	......	......	*						
Eulima gracilis, *Charlesw.*									
—— macrostoma, *Charlesw.*									
—— polygyra, *Charlesw.*									
Fasciolaria funiculosa, *Desh.*	......	......	......	......	......	*			
Fusus (Murex) porrectus, *Brand.* f. 36; (aciculatus, *Lam.*; F. acuminatus, *Sow.*)	......	......	*	......	*	*	......	......	*
—— bulbus, *Br.* ? (Pyrula lævigata, *L.*)	......	*	*	......	......	*	*		
—— canaliculatus, *Sow.* f. 18									
—— carinella, *Sow.*	......	*							
—— errans, *Sow.*	......	......	*	......	......	......	......	*	
—— (Strepsidura) ficulneus, *Lam.* (F. turgidus, *Brand.*)	......	......	*	......	*	*	*	*	
—— (Murex) interruptus, *Sow.*	......	*							
—— Lima, *Sow.*									
—— longævus, *Lam.*	......	......	*	*	*	*	*	......	*
—— porrectus, *Brand.* (F. asper, *Sow.*; F. rugosus, *Lam.*)	......	*	*	......	*	*			
—— pyrus, *Brand.* (F. bulbiformis, *Lam.*)	......	......	*	*	*	*	*	*	
—— regularis, *S.* (Murex antiquus, *Br.*)	......	*	*						
Hipponyx (Pileopsis, *Lam.*) squamæformis, *Desh.*	......	......	*	......	*	*	*		
Littorina sulcata, *Pilk.*	......	......	*						
Marginella bifido-plicata, *Charlesw.*	......	*	*						
—— ? gracilis, *Edw.*									
—— pusilla, *Edw.*									
Melampus tridentatus, *Edw.*									
Melania carinata, *Charlesw.*									
—— costata, *Sow.*									
—— ? fasciata, *Sow.*									
—— marginata, *Lam.*	......	......	*	......	*	*	*	*	
Melanopsis fusiformis, *Sow.*									
Mitra obesa, *Edw.*									

TABLE (*continued*).

Mollusca of the Barton Clay.	Range of species. London area. A. Lower Sands.	B. London Clay.	D. Bracklesham Sands.	Paris area. A. Sables de Bracheux.	C. Lits Coquilliers.	D. Calcaire grossier.	E. Sables Moyens.	Belgian area. D. Système Bruxellien.	E. Système Laekenien.
Mitra parva, *Sow.* (M. pumila, *Sow.*) ...	......	*	*						
—— porrecta, *Edw.*	......	......	*						
—— scabra, *Sow.* (Buccinum scabriculum, *Brand.*)									
—— volutiformis, *Edw.*									
Murex asper, *Br.*(M. tricuspidatus, *Desh.*)	......	......	*	......	......	......	*		
—— bispinosus, *Sow.*									
—— contabulatus, *Lam.*	......	......	......	......	......	*			
—— crispus, *Lam.*	......	......	......	......	......	*			
—— defossus, *Sow.*									
—— frondosus, *Sow.* (M. rudis, *Desh.*) ..	......	*	......	......	......	*	*		
—— minax, *Br.* (Fusus minax, *Lam.*)...	......	*	*	......	......	*	*		
—— tricarinoides, *Desh.*	......	......	......	......	......	*			
—— tripteroides, *Lam.*	......	......	......	......	......	*			
Nassa obtusa, *Edw.*									
Natica ambulacrum, *Sow.*	......	......	*						
—— epiglottina, *Lam.* (N. similis, *Sow.*)	......	......	*	......	*	*	*	*	
—— Hantoniensis (N. striata, *Sow.*) ...	......	*	*						
—— sigaretina, *Sow.*	......	*	......	......	......	......	......	*	
—— labellata, *Lam.*	*	*	*	......	*	*	*	*	
—— mutabilis, *Br.* (N. acuta, *Sow.*) ...									
—— patula, *Lam.*	......	......	*	......	*	*	......	*	
Nerita globosa, *Sow.*									
Odostomia pupa, *Charlesw.*									
—— turgida, *Charlesw.*									
Oliva aveniformis, *Sow.*									
—— Branderi, *Sow.*	......	......	......	......	......	......	*		
—— Salisburiana, *Sow.*									
Paludina concinna, *Sow.*									
Patella									
Pedipes glaber, *Edw.*									
Phasianella.....									
Pleurotoma brevirostrum, *Sow.*									
—— comma, *Sow.*	*	*							
—— (Murex) conoides, *Brand.*									
—— desmia, *Edw.*									
—— exorta, *Brand.*	......	......	*						
—— formosa, *Charlesw.*									
—— granulata, *Lam.*	......	......	*	......	......	*	*		
—— innexa, *Brand.* (P. inflexa, *Lam.*)	......	......	*	......	*	*	*		
—— lanceolata, *Edw.*									
—— lævigata, *Sow.*									
—— macilenta, *Brand.*	......	......	*						
—— microdonta, *Edw.*	......	......	*						

TABLE (*continued*).

Mollusca of the Barton Clay.	Range of species.								
	London area.			Paris area.				Belgian area.	
	Lower Sands. A.	London Clay. B.	Bracklesham Sands. D.	Sables de Bracheux. A.	Lits Coquilliers. C.	Calcaire grossier. D.	Sables Moyens. E.	Système Bruxellien. D.	Système Laekenien. E.
Pleurotoma prisca, *Sow.*	......	*	*	......	......	*	*		
—— rostrata, *Sow.*									
—— semicolon, *Sow.*									
—— colon, *Sow.*	......	*	......	......	*				
—— turrella, *Desh.*	......	......	......	......	*	*			
Pyramidella									
Pyrula Greenwoodi, *Sow.*									
—— (Murex, *Brand.*) nexilis, *Lam.*	......	......	*	......	......	*	*		
Ringicula parva, *Charlesw.*									
—— turgida, *Charlesw.*									
Rissoa Bartonensis, *Charlesw.*									
Rostellaria ampla, *Brand.* (R. macroptera, *Lam.*; Strombus, *Brand.*)	......	*	*	......	*	*	......	* ?	
—— Comptoni, *Edw.*									
—— (Murex, *Brand.*) rimosa, *Sow.* ?	......	......	......	......	......	......	* ?		
Rotella (Helicina, *Desh.*) dubia, *Lam.*	......	......	......	......	*	*	*		
—— minuta, *Sow.*	......	......	*						
Scalaria acuta, *Sow.*	......	......	*	......	......	*			
—— interrupta, *Sow.*	......	......	*						
—— reticulata, *Br.* (semicostata, *Sow.*)	......	......	*						
—— tenuilamella, *Desh.*	......	......	*	......	*	*	......	......	*
—— undosa, *Sow.*	......	*							
Sigaretus canaliculatus, *Sow.*	......	* ?	*	......	......	*	*	*	
Solarium canaliculatum, *Lam.*	......	*	*	......	......	*	*		
—— discoideum, *Sow.*									
—— distinctum, *Edw.* ?									
—— plicatum, *Lam.*	......	......	*	......	......	*	*		
—— spiratum, *Lam.*	......	......	*	......	*	*	*	*	
Strombus Bartonensis, *Sow.* (ornatus, *D.*)	......	......	......	......	......	*			
Terebellum fusiforme, *Lam.*	......	......	*	......	*	*			
—— sopita, *Brand.* (Bulla, *Brand.*; Seraphs convolutus, *Montf.*)	......	......	......	......	......	*	*	*	
Terebra plicatula, *Lam.*	......	......	......	......	*	*	*		
Triton (Murex, *Brand.*) argutus, *Sow.*	......	......	*						
Trochus (Phorus) agglutinans, *Lam.*	......	......	*	......	*	*	*	*	
—— monilifer, *Lam.* (T. nodulosus, *Br.*)	......	......	......	......	......	......	*		
—— patellatus, *Desh.* ?	......	......	......	......	......	......	*		
Turritella brevis, *Sow.*	......	......	......	......	......	......	......	......	*
—— (Turbo, *Brand.*) imbricataria, *Lam.* (T. conoidea, elongata, edita, *Sow.*)	......	*	*	*	*	*	*	*	
Typhis (Murex, *Lam.*) fistulosus, *Sow.*	......	......	......	......	......	*	*		
—— pungens (Murex, *Br.*; M. tubifer, *Lam.*)	......	......	......	......	......	*	*		
Voluta (Strombus, *Brand.*) ambigua, *Sol.*	......	......	......	......	......	......	* ?		

TABLE (*continued*).

Mollusca of the Barton Clay.	Range of species.								
	London area.			Paris area.				Belgian area.	
	Lower Sands. A.	London Clay. B.	Bracklesham Sands. D.	Sables de Bracheux. A.	Lits Coquilliers. C.	Calcaire grossier. D.	Sables Moyens. E.	Système Bruxellien. D.	Système Laekenien. E.
Voluta (Strombus, *Br.*) athleta, *Sow.*	......	......	......	......	......	......	*		
—— costata, *Brand.*									
—— depauperata, *Sow*	......	......	......	......	......	.....	*		
—— humerosa, *Edw.*	......	......	*						
—— digitalina, *Lam.* (V. scabricula, *Brand.*; V. lima, *Sow.*)	......	......	*	......	......	......	*		
—— luctatrix, *Brand.*	......	......	* ?						
—— maga, *Edw.* (Magorum, *Sow.*)	......	......	*						
—— nodosa, *Sow*	......	*	*						
—— scalaris, *Sow.*									
—— Solandri, *Edw.* (Strombus luctator, *Brand.*, fig. 65)									
—— suspensa, *Sow.*									
Volvaria acutiuscula, *Sow.*	......	......	......	......	* ?	......	*		
LAMELLIBRANCHIATA.									
Arca appendiculata, *Sow.*									
—— barbatula, *Lam.*	......	......	*	......	......	*	*	* ?	
—— Branderi, *Sow.*	......	......	*						
—— duplicata, *Sow.* (A. lactea, *Brand.*)	......	......	*						
Capsa tenera, *Edw.*									
Cardilia radiata, *Sow.*									
Cardita acuticosta, *Lam.* (V. carinata, *S.*)	......	......	*	......	......	*	*	......	*
—— deltoidea, *Sow*									
—— oblonga, *Sow.*									
—— (Chama) sulcata, *Brand.* (V. coravium, *Lam.*?; V. globosa, *Sow.*)	......	......	......	......	......	......	*		
Cardium discors, *Lam.*	......	......	......	......	*	*	*		
—— porulosum, *Brand.*	......	......	*	*	*	*	*	*	*
—— turgidum, *Brand*	......	......	......	......	......	......	......	......	*
—— var. semigranulosum, *Desh*	......	......	* ?	......	......	......	*	*	*
Chama squamosa, *Br.* (C. turgidula, *Lam.*)	......	......	......	......	......	......	*		
Clavagella coronata, *Desh.*	......	......	*	......	......	......	*	*	
Corbula costata, *Sow.* (C. revoluta, *Sow.*)	......	......	*						
—— Ficus, *Brand.* (Solen, *Brand.*; C. umbonella, *Desh.*)	......	......	......	......	* ?	......	*	* ?	*
—— gallica, var., *Lam*	......	......	*	*	*	*	*	*	*
—— Pisum, *Sow.*	......	......	*	......	......	......	......	......	*
—— striata, *Lam.*	......	......	*	......	*	*	*	*	* ?
Crassatella plicata, *Sow.*	......	......	*	......	......	......	......	......	*
—— sulcata, *Sow.* (C. lamellosa, *Lam.*)	......	......	......	......	......	*			
—— tenuisulcata, *Edw.*									
Cypricardia pectinifera, *Sow.* (Venus, *S.*)	......	......	*	......	......	......	......	......	*

TABLE (*continued*).

Mollusca of the Barton Clay.	Range of species. London area. Lower Sands. A.	London Clay. B.	Bracklesham Sands. D.	Paris area. Sables de Bracheux. A.	Lits Coquilliers. C.	Calcaire grossier. D.	Sables Moyens. E.	Belgian area. Système Bruxellien. D.	Système Laekenien. E.
Cyrena cycladiformis, *Desh.*? (Erycina lævis, *Lam.*)	......	......	......	......	*	*			
—— obovata, *Sow.*									
Cytherea elegans, *Lam.* (Venus gallina, *Brand.*)	......	......	*	......	......	*	*		
—— pusilla, *Desh.*	......	......	......	*	......	......	......	......	* ?
—— rotundata, *Br.* (V. lineolata, *Sow.*)									
—— tellinaria, *Lam.*	......	......	......	......	......	*	*		
—— transversa, *Sow.*									
Gastrochæna (Fistulana, *Lam.*) ampullaria, *Lam.*	......	......	......	......	......	*			
—— contorta, *Sow.*									
Isocardia									
Kellia pisiformis, *Charlesw.*									
Limopsis scalaris, *Sow.* (Pectunculus)									
Lucina albella, *Lam.*	......	......	......	......	*	*	*		
—— ambigua, *Defr.*	......	......	......	......	......	......	*	......	* ?
—— concentrica, *Lam.*	......	......	......	......	......	*	*	*	
—— divaricata, *Lam.*	......	......	......	*	*	*	*	*	*
—— gigantea, *Desh.*	......	......	......	......	......	*			
—— Menardi, *Desh.*	......	......	......	......	......	......	*		
—— mitis, *Sow.*	......	......	*						
—— radiata, *Edw.*	......	......	*						
—— Saxorum, *Lam.*	......	......	......	......	......	*	*	......	*
—— spinulosa, *Edw.*	......	......	*						
Modiola seminuda, *Desh.*	......	......	......	......	......	......	*		
—— sulcata, *Lam.*	......	......	......	......	......	*	*		
Neæra (Corbula, *Desh.*) argentea, *Lam.*	......	......	*	......	......	*	......	......	*
—— cochlearella, *Desh.*	......	......	......	......	......	*			
Nucula bisulcata, *Sow.*	......	......	*						
—— minima, *Sow.*	*	*	*						
—— similis, *Sow.* (N. margaritacea, *Dh.*)	*	*	*	......	*	*	*	*	*
—— trigona, *Sow*									
—— deltoidea, *Lam.* ?	......	......	......	......	*	*	*		
Panopæa intermedia, *Sow.* ?	......	*	......	......	......	......	......	*	
Pectunculus (Arca) deletus, *Brand.* (P. costatus, *Sw.*; P. angusticostatus, *D.*?)	......	......	......	......	......	......	*		
Pholodamya									
Pholas conoidea, *Desh.*	......	......	......	......	* ?	......	*		
Sanguinolaria compressa, *Sow.*	......	*	*						
Solen (Cultellus) affinis, *Sow.*	......	*							
—— gracilis, *Sow.*									
—— vaginalis, *Desh.*	......	......	*	......	*	*	*	*	
Solenocurtus Parisiensis, *Desh.*	......	......	*	......	......	*	......	......	*

TABLE (*continued*).

Mollusca, &c., of the Barton Clay.	Range of species. London area. A. Lower Sands.	London area. B. London Clay.	London area. D. Bracklesham Sands.	Paris area. A. Sables de Bracheux.	Paris area. C. Lits Coquilliers.	Paris area. D. Calcaire grossier.	Paris area. E. Sables Moyens.	Belgian area. D. Système Bruxellien.	Belgian area. E. Système Laekenien.
Syndosmya convexa, *Charlesw.*									
Tellina ambigua, *Sow.*									
—— Branderi, *Sow.* (T. bimaculata, *Br.*)									
—— donacialis, *Lam.*	......	*	*	*	*	*	*		
—— filosa, *Sow.*	......	......	*						
—— granulosa, *Edw.*									
—— Hantoniensis, *Edw.*									
—— lævis, *Edw.*									
—— lamellulata, *Edw.*									
—— scalaroides, *Lam.*	......	......	*	......	*	*	*		
—— squamula, *Edw.*									
Teredo									
Anomia lineata, *Sow.* (A. tenuistriata, *Dh.*)	......	*	*	*	*	*	*	*	*
Avicula media, *Sow.*	......	*	*						
Ostrea dorsata, *Desh.*	......	......	*	......	......	*	*		
—— flabellula, *Lam.* (Chama plicata, *Br.*)	......	......	*	......	*	*	*	*	*
—— gigantea, *Sow.* (O. latissima, *Desh*).	......	......	......	......	......	*	*	*	*
Pecten carinatus, *Sow.*									
—— plebeius, *Sow.*	......	......	*	......	......	......	......	*	*
—— reconditus, *Brand.*	......	......	*						
Pinna									
Vulsella deperdita, *Lam.*	......	......	......	......	......	*			
Brachiopoda.									
Terebratula bisinuata, *Lam.*	......	......	......	......	......	*			
	6	36	103	10	47	82	77	32	31
Crustacea (*Entomostraca*).									
Cytherc Wetherellii, *Jones*									
—— striatopunctata, *Rœmer*	......	......	*	*?	*?	*	*	*?	
—— attenuata, *Jones*									
—— consobrina, *Jones*									
—— plicata, *Münster*	......	......	*						
—— (Cythereis) horrescens, *Bosq.*	......	......	*	*?	*?	*	*		
—— (Cythcridea) Mulleri, *Münst.*	......	......	......	......	......	*			
—— —— debilis, *Jones*									
—— —— perforata, *Rœmer*	......	*	......	......	......	*	*		
—— (Cytherideis) Bartonensis, *Jones*									
—— (Bairdia) subdeltoidea, *Münst.*	......	*	......	......	......	*	*	*	
—— —— contracta, *Jones*									
—— (Cytherella) Munsteri, *Rœm.*	......	*	*	*?	*?	*	*		

Table (*continued*).

Zoophyta, &c. of the Barton Clay.	Range of species.								
	London area.			Paris area.				Belgian area.	
	Lower Sands. A.	London Clay. B.	Bracklesham Sands. D.	Sables de Bracheux. A.	Lits Coquilliers. C.	Calcaire grossier. D.	Sables Moyens. E.	Système Bruxellien. D.	Système Laekenien. E.
Cirripedia.									
Balanus unguiformis, *Sow.*									
Annelida.									
Serpula crassa, *Sow.*									
—— exigua, *Sow.*									
—— extensa, *Brand.*									
—— heptagona, *Sow.*	......	*	*						
—— ornata, *Sow.*	......	......	*						
Ditrupa strangulata, *D.* (incrassata, *S.*)	......	*	......	......	......	*	*		
Echinodermata.									
Cidaris Websteriana, *Forb.*	......	*							
Echinus Dixonianus, *Forb.*									
Echinopsis Edwardsii, *Forb.*	......	......	*						
Hemiaster Branderianus, *Forb.*	......	*?							
Eupatagus Hastingiæ, *Forb.*									
Schizaster D'Urbani, *Forb.*									
Spatangus Omalii, *Gal.*	......	......	......	......	......	......	......	*	
Ophiura Wetherelli, *Forb.* ?	......	*							
Zoophyta.									
Turbinolia Bowerbankii, *M.-Ed.*									
—— Fredericiana, *M.-Ed.*									
—— humilis, *M.-Ed.*									
—— minor, *M.-Ed.*									
—— firma, *M.-Ed.*									
Holarea Parisiensis, *M.-Ed.*	......	......	......	......	......	*			
Graphularia Wetherelli, *M.-Ed.*	......	*							
Foraminifera.									
Nummulites variolarius, *Lam.*	......	......	*	......	......	......	*	*?	*
Anomalina.									
Glandulina.									
Globulina.									
Polymorphina.									
Quinqueloculina.									
Rotalina.									
Triloculina.									

Table (*continued*).

Pisces, &c. of the Barton Clay.	Range of species.								
	London area.			Paris area.				Belgian area.	
	A. Lower Sands.	B. London Clay.	D. Bracklesham Sands.	A. Sables de Bracheux.	C. Lits Coquilliers.	D. Calcaire grossier.	E. Sables Moyens.	D. Système Bruxellien.	E. Système Laekenien.
Reptilia.									
Chelone									
Pisces.									
Lamna									
Myliobatis marginalis, *Ag.*									
—— nitidus, *Ag.*	......	*							
Ætobatis subarcuatus, *Ag.*	......	*							
Notidamus serratissimus, *Ag.*	......	*							

§ 5. *Concluding Remarks—Physical conditions prevailing at the Paris Tertiary Period.*

I have named that portion of the Eocene series, of which the foregoing deposits form the centre and type, the "Paris Tertiary Group *," because it is in the Paris area that this group is most complete and best exhibited, and that the animal life of the period has been most perfectly developed. Of marine Testacea alone above 1200 species existed in the French area †, whilst in the English area they were apparently but about half that number. A somewhat similar proportion appears to hold good with respect to the Corals, Echinoderms, and Foraminifera; but of Fishes, Reptiles, and Crustacea, the English series shows a considerable preponderance.

The Paris group originated, as I have before mentioned, with the period of the Lower Bagshot Sands and Glauconie moyenne in the subsidence of a southern land and extension of the sea ‡ over the previously littoral and dry portions of the Paris district, leading to the introduction of the Nummulitic fauna and of forms indicating

* This is nearly synonymous with M. Alc. D'Orbigny's "Système Parisien," but he includes in this the "London Clay" and excludes the "Lits Coquilliers;" whereas I consider the London Clay older than the Lits Coquilliers, and as the centre of another (the London) group; the Lits Coquilliers and Glauconie moyenne I would place in the Paris group.

† The supplement now in course of publication by M. Deshayes for his great work on the Fossil Shells of the Paris Tertiaries promises to add largely to the number already known—even to the extent of nearly doubling that number.

‡ I think it probable that the sea of the London area became connected at this period with a southern sea by the depression of the intermediate land.

warmer seas. A further but minor change afterwards took place, marking the commencement of the Bracklesham Sands and the Calcaire grossier period : the former sea-bed seems to have been enlarged and further extended, and a fauna of a still more southern facies introduced—which fauna, fixing upon the favourable localities in the French area, multiplied exceedingly *.

In reviewing the general characters of that portion of the Paris group which succeeds at this last change, we cannot fail to be struck with the distinctive physical features of the French and English formations, and by the less independent nature of their Belgian equivalent. That the three areas, however, were at the Paris geological period closely connected and partially continuous, seems to be proved both by the occurrence of some intermediate tertiary outliers †, and by a certain amount of common mineral elements and structural peculiarities. At the same time there were, as we have before noticed, important specific differences in the organic remains and in the volume of the deposits; but these zoological and physical differences are such as would apparently have resulted more from the variable character of the sea-bed and from the different rate of subsidence or elevation affecting each district, than from the isolation of any of these sea-areas.

The period of the Lower Bracklesham Sands and of the two lower divisions of the Calcaire grossier was, in the Paris area, after the introductory somewhat sudden disturbance, one of comparatively little change—there was a calcareous sea-bed and an absence of muddy sediment, consequently conditions peculiarly favourable for the existence of a rich and varied testaceous fauna, such as then became there developed. Whilst this comparative tranquillity prevailed in the French area, in England a more rapid subsidence was, by giving greater depth to the sea, tending to increase the vertical dimensions of the strata ; and at the same time causing, either by too sudden a change of depth or by too rapid an accumulation of sediment, occasional intervals during which particular parts of the sea-bed were depopulated of those Molluscs which flourished in the same area under other more favourable conditions that intervened from time to time. At the same time the more argillaceous character of the silt in the seas of the English area was calculated to foster the existence of many local species; whilst, on the other hand, such a sea-bed was not favourable to the immigration of a greater proportion of the French species. These were causes which must necessarily have stamped the animal life of the two areas with certain peculiarities distinctive of each, and may, in great part, account for so large a number of species being confined to the French and English districts respectively.

Notwithstanding the extent of this Tertiary sea over the north of

* As the Glauconie moyenne overlaps the æstuarine and freshwater beds of the "Argile Plastique," so does the Calcaire grossier overlap the Glauconie moyenne, extending further south and south-east than the latter.

† Of the lower beds principally, but also of the Lower Bagshot Sands and Glauconie moyenne when the hills are high enough.

France, south-east of England, and south of Belgium, it is evident that dry land existed near the first two of these tracts; for in the English series there are several beds of lignite, and fragmentary * remains of vegetables are dispersed in abundance through many of the strata; and in the French series are found the remains of plants, of land and freshwater shells, and of land animals. There is, however, a difference in the floras, which renders it not improbable that these two land-areas were not connected; for the French flora, which is not large, is the more tropical, consisting chiefly of some species of large Palms; whereas the English flora, as far as we can judge from very imperfect indications, exhibits apparently a more varied vegetation, but one of a different character. (If the leaf-beds of Alum Bay and of Bournmouth should be found to belong to the Bracklesham series, then we have species related to laurel, fig, maple, yew, zamia?, &c.)

Supposing, therefore, such to have been the distribution of land and water, we see a cause why, notwithstanding the presumptive evidence of a common sea, the deposits going on in that sea being derived from two lands, there would be, in all probability, a difference in the character of the coast-sediments †.

Passing upwards to the third division of the Calcaire grossier, there is a rapid increase in the number of æstuarine, freshwater, and land shells; leading to the inference, not so much that the French area was rising, as that the æstuary, or gulf, in which the Calcaire grossier was accumulating, was gradually silting up; whilst in the English area a continued subsidence preserved the depth of sea and kept up the marine population. [See note § at p. 134.] This distinction attains its maximum in the upper part of the Calcaire grossier, which seems to be almost entirely fresh water, whereas the upper beds of the Bracklesham series continue to exhibit purely marine characters.

That these deposits were continuous during the Paris Tertiary period is in accordance with the sketch given of the structure of the Calcaire grossier in the preceding pages, where it is shown that the resemblance in mineral structure of the French to the English series increases from east to west, or as the French series ranges towards the English area; at the same time that the differences diminish in the same direction. Thus the beds of mixed green sands, thin at the base of the

* Many of the leaves, both in the French and English strata, are extremely well preserved, and were evidently carried but a short distance out to sea.

† Still, admitting the operation of all these varied geographical and structural conditions, it may be a question, although they may account for certain *generic* differences in the French and English faunas, whether, on the other hand, such extremes of conditions may not also have modified, to a greater extent than is at present admitted, the form and size of the same species in the different areas, and have been the cause of extreme *specific* differences. Looking at the separate marine faunas of the Calcaire grossier and of the Bracklesham Sands, we find a certain number of species common to the two, but a far larger proportion peculiar to each area. Such, necessarily, must be the case, to a certain extent, in sea-beds so differently constituted; nevertheless we cannot fail to remark on the fact, that, even where there is no relation in species, still there is often a marked concordance in genera,—in many cases the species of various genera existing in each area in the same relative proportion: thus, amongst others, the following 11 genera are in nearly equal force in both countries, nevertheless out of the

Calcaire grossier in the east of the Paris basin, expand as they range westward, giving indications of the development which they attain

136 species of which they consist there have only been 14 identified as common to the French and English series. This is shown in the following Table.

*Bracklesham Sands and Calcaire grossier *.*

Genera common to the two areas.	Total number of species.		Species common to both countries.
	France.	England.	
Nautilus	2	2	0
Ancillaria	6	4	2
Bulla	9	9	0
Cassidaria	3	3	1
Conus	5	5	2
Cypræa	5	4	2
Dentalium	12	4	1
Rostellaria	3	3	1
Scalaria	8	7	2
Lucina	15	12	0
Tellina	13	16	3
	81	69	14

So in the next period another 10 genera with a total of 121 species show only 13 in common.

Barton Clay and Sables Moyens.

Genera common to the two areas.	Total number of species.		Species common to both countries.
	France.	England.	
Cypræa	3	2	0
Fusus	16	13	5
Marginella	2	3	0
Melania	8	4	1
Mitra	5	5	0
Oliva	3	4	1
Pleurotoma	17	16	3
Voluta	12	12	3
Crassatella	2	3	0
Pecten	2	3	0
	70	64	13

The same remarks may be made of some of the Zoophytes: thus there are four specise of *Turbinolia* in the Sables moyens, and five in the Barton Clay, all considered different. Of ten *Serpulæ* on one side and five on the other, none agree.

The species seem to be representative species ; yet would I ask palæontologists to consider in such cases, when the definite synchronism of certain strata is established upon structural and general grounds, how far some of these apparent differences in the species may be varieties brought about by the great differences of

* The number of French species are those given by M. Graves.

at Bracklesham. Whereas the freshwater marls at the top of the Calcaire grossier have their maximum development in the east of the Paris area, and gradually thin out as they range westward, disappearing nearly, if not altogether, before we reach its western confines; wherefore the absence of like conditions in the English area is thus *à priori* shown to be probable.

In Belgium there was neither the amount of subsidence experienced in England nor the extent of silting up going on as in France; the Bruxellian System with even less vertical dimensions than its French equivalent, and a fauna less extensive than its English equivalent, exhibits throughout the same marine characters as the latter. Also the land seems to have been at a greater distance: there are remains of a land-vegetation, but composed of specimens which seem to have been drifted from a distance; for it is the harder fruit (*Nipadites*) and not the more delicate leaves of the Palm which there occur; and they are often drilled by *Teredinæ*, as though they had long floated out at sea.

The next change is, in the French area, one of a very marked character: marine strata of entirely different composition to the Calcaire grossier overlie that deposit, and at the base of this upper deposit are scattered here and there the debris and wreck of the older tertiary beds and of the chalk. A sudden change, I believe, here took place: the æstuaries, bays, and gulfs of the Calcaire grossier were invaded by the sea. That the movement was sudden, and of some considerable force, I infer from the circumstance that the consolidated beds of the Calcaire grossier, including even its upper freshwater marls with the chert beds, together with the solid beds of the Glauconie moyenne and Glauconie grossière, were partially broken up and denuded; for rolled fragments of all these beds are found in places at the base of the Sables moyens, and at a considerable distance from where the lower beds rise from beneath the Calcaire grossier. With these rock-debris are also found the harder and larger rolled shells of the Sables de Bracheux, and the shells of the Argile plastique; whilst well-worn small flint-pebbles form the main part of this conglomerate-bed—pebbles probably formed on the shores of the Calcaire grossier sea, and scattered at this subsequent period. Once spread over the bed of the sea, and the state of tran-

sea-bed, temperature, depth, &c.—whether these causes have not operated to a greater extent than is here allowed. In these instances the conditions are so strongly marked, that they lead me to believe that such an amount of variation may have been thereby produced as might, viewing each area separately and independently, cause some varieties to assume the permanence and importance of specific differences; and I therefore think it not improbable that eventually there will be found a greater number of species common to the two countries.

Until the exact synchronism of any deposit is established, the palæontologist cannot in each case take the actual value of these causes into full and sufficient consideration, and many admirable monographs on Tertiary fossils have necessarily been founded simply upon the differences actually apparent and persistent in the fossils of the several areas, after allowing for such differences as do take place in each respective area separately. The limits of variations require, however, to be studied for the several areas conjointly.

quillity restored, then these pebbles of the older Tertiaries were subjected to the attacks of boring molluscs, and small corals grew amongst the pebbles. The sea-sediments now changed entirely: quartzose sands, derived from other shores and different sources, and forming the main and common mineral element in the two countries, are substituted for the calcareous deposits of the Calcaire grossier. In England a change of nearly like value took place: the alternating sandy beds of the Bracklesham Sands are suddenly succeeded by a thick mass of compact clays and quartzose sands, the change being marked by a thin but continuous bed of well-rounded chalk-flints strewed over the bed of the sea in which the Barton Clay commenced its formation. Some of these pebbles are as large as cannon-balls; they are evidently removed from the position in which they were formed, for they usually overlie loose sands—a floor on which the flints could not have been worn down as we now find them.

Accompanying this break in the sequence and this change in the mineral character, a partially new fauna appears in both areas, but still many of the old forms remain. The change in this respect in the English and French areas is about equal in degree.

A long period of rest now succeeded, during which the lower beds of the Sables moyens, with their large and varied fauna, were formed. In England the same relatively greater amount of subsidence which we noticed at the former period was continued in this one: the Barton Clay is many times thicker than the corresponding beds of the Sables moyens. The fossils in it are not so numerous, and are much dispersed. Other changes then succeeded in the French area; and probably the sea again became more restricted*. In Belgium the change appears less marked.

The Barton-clay sea seems again to have been more connected with water opening to the northward than did that of the Bracklesham Sands; for several species of the London-clay sea, which, as I have before shown, was probably connected with northern seas, that had disappeared in the intermediate Bracklesham period, reappear in the Barton series. In fact the fauna of this group, together with that of the Sables moyens, has not so southern an aspect as that of the Calcaire grossier and Bracklesham period.

It is interesting to note the evident migration of species going on all through these periods. Many physical changes, some slow and others rapid, took place from time to time; many of them were only local, whilst several extended over wider tracts and affected the several areas, but in such cases we find that the effects were in some places stronger than in others. It would seem that larger or smaller portions of the fauna of each period or of each subdivision were in all instances preserved and transmitted or continued upwards. Some-

* M. D'Archiac has suggested that the great accumulation of barren sands on the north-eastern edge of the area of the Sables moyens are probably the dunes of an old land (D'Archiac, Progr. de la Géol. vol. ii. p. 571). The large shingle beds mentioned by M. Graves might also suggest that land was not far off—possibly part of the Pays de Bray might at this period have been an island with ranges of chalk cliffs.

times this seems to have been effected by direct vertical transmission. At other times many species appear to have been destroyed in some particular part of the area at the period of these changes, or rather, the change brought about unsuitable conditions whereby they were temporarily displaced. Yet nevertheless, when during a recurrence of somewhat similar conditions, subsequent immigrations introduced at a later period a comparatively distinct newer fauna, many of these old forms which had been preserved in the less disturbed districts, and had there remained, as it were, in exile during the whole, or during one or more divisions, of an intervening period, returned.

At other times some species seem to have travelled more rapidly or more readily in a horizontal than in a vertical direction; and thus many forms, which are common in some particular zone in one area and absent in the adjacent ones, seem, in process of time, to have migrated into these latter, and flourished there in the next subsequent geological period; whereas in the area in which they first appeared they have not been transmitted upwards, and are not found in these newer beds. Thus, though extinct in one area, they may continue to mark a higher series in an adjacent area.

It is also a point of very considerable interest to note how constant and steady is the progression of change in the several subdivisions of each formation. The disappearance of some species and the appearance of new species seem continued quite apart from those great breaks which from time to time give abruptness and prominence to a law equally operative throughout all time.

How far the Upper Bagshot Sands are related to the Bracklesham series it is difficult to say. The few fossils I have found in those sands are not sufficiently distinctive to enable me to pronounce a decided opinion. As, however, the fossiliferous Middle Bagshot Sands are very thin, and represent apparently only the lower or middle part of the Bracklesham series, I think it probable that it is the upper beds of sand and clay of the latter which pass northward into the thick sands of the Upper Bagshot Sands. Still it is possible that part of them may represent the Barton series, for we see at Barton how shifting the upper part of that series is—how clay predominates at one place and sands at another *. If we had to limit the Calcaire grossier series at Cassel to the beds beneath the *Nummulites variolarius* zone, it would render the latter view the more probable. I now, however, there give that series greater dimensions than I did in my last paper (see Pl. VIII. vol. xi. p. 241).

We are now at the conclusion of an important section of the Eocene period. The changes we have traced thus far have been essentially under marine conditions. We already begin to perceive

* The occurrence in the middle beds of the Sables moyens of blocks of saccharoid sandstones traversed with rootlet-shaped casts and impressions has its counterpart in the blocks of sandstone lying on the top of the Upper Bagshot Sands in the Bagshot district.

indications of the withdrawal of the sea, and of the presence of bodies of fresh water in the upper part of the Calcaire grossier. These, however, are displaced for a time, and the sea of the Sables moyens covers the whole of the French, English, and probably the Belgian areas ; but at the point where we now leave off, the sea begins to shift its bed from over the greater part * of this more extended area and for a much longer and more settled period. Fresh and brackish water conditions of singular variety and interest set in, and are continued with few breaks (sufficient, however, to show the proximity of the sea and of a marine fauna but little changed) up to another and more general change, and the introduction of a fauna, both marine and freshwater, in greater part new and distinct.

Of these changes, and of the correlations prevailing in the three areas under review, during the further continuance of this Eocene period, I hope to treat on a future occasion, having confined the inquiry at present to that part of the Barton series represented by the clay-beds at Barton and forming its lower division.

Table of Synchronous Strata of that portion of the Paris Tertiary Group treated of in this Paper.

English Area.	Belgian Area.	French Area.
Barton Clay.	Systême Laekenien.?	Sables Moyens—lower zone.
Bracklesham Sands { Upper. Middle. Lower.	Systême Bruxellien.	Calcaire grossier & Glauconie grossière. { Freshwater marls. Upper flags. Freestone. Greenish sands.
Lower Bagshot Sands.	Systême Ypresien supérieur.	Lits Coquilliers and Glauconie Moyenne.

The subdivisions of the Bracklesham Sands here introduced are merely nominal, as they present no marked or permanent limits ; the middle of the series is, however, distinguished by the greater abundance of fossils at White Cliff Bay (see p. 99). To the sands underlying the Bracklesham series, and forming possibly a lower division thereof, I think it more convenient to restrict the term of Lower Bagshot Sands, although both in the Isle of Wight and on the Hampshire coast they seem, in structure, to form part of one like series of strata.

The Glauconie grossière includes the Glauconie supérieure of M. Graves. With the Lits coquilliers of D'Archiac, I include the Glaises † and Sables divers, *i. e.* I take his upper three divisions of his group of Sables Inférieurs together. The Glauconie Moyenne I take as defined by M. Graves.

* Partially only from off the Belgian area. † This with a doubt.

Range and Distribution of the Mollusca of the Bracklesham Sands and Barton Clay in the English and French Eocene marine series, with the comparative range of species in each series separately.

	Total number of species.	Peculiar species.†	Species found in lower beds.	French area.			
				Species common to the Sables Moyens.	Species common to the Calcaire grossier.	Species common to the Lits Coquilliers.	Species common to the Sables Inférieurs.
Barton Clay	252	140	112	77	82	47	10
Bracklesham Sands	368*	221	56	94	142	75	15

	Total number of species.	Number of peculiar species.	Species found in the underlying beds.	English area.		
				Species common to Barton.	Species common to Bracklesham.	Species common to the London Clay.
Sables Moyens	377	150?	226	77	94	13
Calcaire Grossier	651	360?	182	82	142	17

* This and the two following numbers will have to be slightly increased and modified by the addition of the species recently described by Mr. Edwards in the Monographs of the Palæontographical Society. The Bracklesham figures under the French area have been corrected to that extent.

† With reference only to the strata on this and lower levels. In the two French series I cannot pretend to much accuracy, as the data are not yet sufficient, and the French geologists are not agreed upon many identifications.

[Note § to p. 128.—Or I can suppose the slow small rise of a tract between the French and English areas, in the direction of the coasts of Normandy and Brittany, partly isolating the French area, gradually shutting out the sea, and giving, on a large scale, a partly lenticular form to the upper divisions of the Calcaire grossier; the centre of the French area, in the mean time, remaining at rest, and the English area subsiding.]

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From July 1st, 1856, to October 31st, 1856.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

American Journal of Science and Arts. 2nd Ser. Vol. xxii. No. 64. July 1856. *From Prof. Silliman, For. Mem. G.S.*

J. Henry.—Testing building-materials, marbles, &c., 30.
J. D. Witney.—Occurrence of the ores of iron in the Azoic System, 38.
Explorations and Surveys for the Pacific Railroad, 67.
C. N. Shepard.—New minerals, 96.
J. B. Trask.—Earthquakes in California from 1812 to 1855, 110.
J. Leidy.—Fossil Reptiles and Fishes from Nebraska, 118.
B. F. Shumard and L. P. Yandell.—Eleutherocrinus from the Devonian limestone of Kentucky, 120.
I. Lea.—Reptilian remains in the New Red Sandstone of Pennsylvania, 122.
H. Wurtz.—Analysis of the water of the Delaware River, 124.
C. Lyell.—Successive changes of the Temple of Serapis, 126.
J. Safford.—Geological survey of Tennessee, 129.

———. No. 65. September 1856. *From Prof. Silliman, For. Mem. G.S.*

J. W. Mallet.—A Zeolitic Mineral (allied to Stilbite) from the Isle of Skye, 129.
R. I. Murchison.—Letter on the Museum of Practical Geology of Great Britain, 232.
J. M. Safford.—The genus Tetradium (a Silurian coral), 236.
E. Hitchcock, Jun.—A fossil shell from the Connecticut Sandstone, 239.
T. Coan.—The Eruption at Hawaii, 240.
J. D. Dana.—Third Supplement to Dana's Mineralogy, 246.
Mitscherlich.—Selenium and Iodine, 271.
W. Eberhard.—Meteoric Iron of Thuringia, 271.
Uricoechea and Böcking.—Meteoric Iron of the Cape of Good Hope, 272.

American Journal of Science and Arts. No. 65 (*continued*).
F. Wöhler.—Meteoric Stone of Mezö-Madaras in Siebenburg, 272.
C. St. C. Deville.—The Volcanos of Southern Italy, 272.
Renaud.—The Isthmus of Suez, 273.
E. de Rivero.—The Mines of Coal in Peru, 274.
H. Witt.—Analysis of the waters of Lake Urumia, 276.
N. S. Maskelyne.—The Koh-i-noor Diamond, 278.
J. W. Bailey.—The origin of greensand, and its formation in the present oceans, 280.
Eckfeldt and Dubois.—Specific gravity apparatus : Californian gold-quartz, 294.
W. B. Rogers.—Palæozoic fossils in Eastern Massachusetts, 296.
A. S. Piggott.—Monks Island guano-rock, 299.
A. A. Hayes.—Monks Island guano-rock, 300.
F. Moldenhauer.—Waters of the Dead Sea, 301.
A. Moritz.—Waters of the Caspian, 301.
J. P. Lesley's Manual of Coal, noticed, 302.

Annuaire des Marées des Côtes de France pour l'An 1855, par A. M. R. Chazallon. 12mo. Paris. 1855.

Athenæum Journal for July, August, September and October, 1856. *From W. Dilke, Esq., F.G.S.*
Notices of Meetings of Societies, and
Obituary Notices.

Bengal Asiatic Society, Journal. New Series, No. 78. 1856. No. 1.
H. Schlagintweit.—Magnetic Survey in Sikkim, the Khasia Hills, and Assam, 1 (plates).

———. ———. ———. No. 79. 1856. No. 2.
A. and R. Schlagintweit.—Magnetic Survey in the Himalayas, 105.
H. Piddington.—Silt held in suspension in the Hooghly, 151.

———. ———. ———. No. 80. 1856. No. 3.
H. Piddington.—Examination of three specimens of Bengal mineral waters, 190.

———. ———. ———. No. 81. 1856. No. 4.
S. F. Hannay.—Iron-ore Statistics and Economic Geology of Upper Assam, 330.

Bent's Monthly Literary Advertiser. Nos. 627, 628, 629.

Berlin. Abhandlungen der Königl. Akad. d. Wiss. zu Berlin. Aus dem Jahre 1854. Erster Supplement-Band. 1856.

———. Monatsbericht der Königl. Preuss. Akad. der Wissensch. zu Berlin. Juli–December 1855.
C. G. Ehrenberg.—Nachricht über die gelungene Darstellung ganzer Steinkerne von Nummuliten, 487.
—— Ueber die gelungene durschsheinende Färbung farbloser organischer Kieseltheile für mikroskopische Zwecke, 552.
—— Beiträge zur Kenntniss der Flusstrübung und der vulkanischen Auswurfstoffe, 561.
—— Ueber das Fortrücken des Supplementes zur Mikrogeologie, 779.

Berlin. Monatsbericht der Königl. Preuss. Akad. der Wissensch. zu Berlin (*continued*).

H. Rose.—Ueber das Quecksilber-haltende Fahlerz von Poratsch oder Kotterbach in Ungarn, 547.

—— Ueber die Zusammensetzung der Beryllerde, 581.

F. Schulze.—Ueber das Vorkommen wohlerhaltener Cellulose in Braunkohle und Steinkohle, 676.

G. Rose.—Ueber den Sehaumkalk als Pseudomorphose von Aragonit, 707.

———. Zeitschrift der Deutschen geologischen Gesellschaft. Vol. viii. No. 1. Nov. 1855–Jan. 1856.

Proeeedings of the Soeiety, 1 ; Letters, 18.

Beyrich.—Die Conchylien des norddeutsehen Tertiärgebirges (4th part), 21 (10 plates).

Bornemann.—Ueber die Diluvial- und Alluvial-Bildungen der Umgegend von Mühlhausen im Gebiete des oberen Unstrutthales, 89.

H. Rose.—Ueber den Carnallit, eine neue Mineralspecies, 117.

L. Meyn.—Riffsteinbildung im Kleinen an der deutsehen Nordseeküste, 119.

E. Suess.—Ueber Catantostoma elathratum G. Sandb., 127 (figs.).

W. von der Marek.—Chemische Untersuchung von Gesteinen der oberen westfälischen Kreidebildungen, 132.

———. ———. ———. Part 2. Feb.–April 1856.

Proeeedings and Letters, 151, 162.

Jenzsch.—Beiträge zur Kenntniss einige Phonolithe des böhmischen Mittelgebirges. Mit besonderer Berüeksiehtigung des Baues dieses Gebirges, 167.

Von Schauroth.—Ein neuer Beitrag zur Paläontologie des deutsehen Zechsteingebirges, 211 (plate).

Ferd. Roemer.—Notiz über ein eigenthümliehes Vorkommen von Alaunstein in der Steinkohle bei Zabrze in Obersehlesien, 246.

E. F. Koch.—Die anstehenden Formationen der Gegend von Dömitz, 249 (map).

R. Hensel.—Beiträge zur Kenntniss fossiler Säugethiere, 279 (plate).

G. vom Rath.—Ueber die Chemisehe Zusammensetzung zweier Phonolithe, 291.

Bombay Geographical Society, Transactions, vol. xii. 1856.

Buist.—Prineipal depressions on the Surface of the Globe, vii.

—— Survey of the Shores off Bombay, by Capt. Selby, xx.

—— Colour of the Red Sea ; Earthquakes in Bengal, &e., Appendix, 5.

Woodburn.—Former Climate of Sinde, App. 7.

—— Sambur Salt-lake, Rajpootana, App. 15.

Breslau und Bonn. Nova Acta Acad. Cæs. Leop.-Carol. Nat. Cur. vol. xxv. part 2. 1856.

E. F. Glocker.—Neue Beiträge zur Kenntniss der nordischen Gesehiebe und ihres Vorkommens in der Oderebene um Breslau, 767.

G. Jäger.—Ueber eine neue Species von Iehthyosauren (Ichth. longirostris, Owen et Jaeger), 937 (plate).

British Association for the Advancement of Science, Report for 1855. 1856.

T. Dobson.—Relation between Explosions in Coal-mines and revolving Storms, 1.
J. F. Bateman.—Supply of Water to Towns, 62.
B. Powell.—Luminous Meteors, 79.
Report on Typical Objects in Natural History, 108.
A. S. Farrar.—Eruption of Vesuvius of 1855, 55.
J. B. Edwards.—Titaniferous iron-sand of the Mersey Shore, 61.
E. Frémy.—Extraction of metals from the ore of Platinum, 63.
J. H. Gladstone.—Crystalline Gypsum from the Reservoir of the Highgate Waterworks, 63.
A. Matthiessen.—Metals of the Alkaline Earths, 66.
T. H. Rowney.—Composition of three mineral pigments (Vandyke-brown, Indian red, Raw Sienna), 70.
R. Allan.—Haukedale Geysers of Iceland, 75.
E. Belcher.—Fossils (Ichthyosaurian and others) found by the Arctic Expedition in 1852–54, 79.
J. Bryce.—Glacial phænomena of the Lake District of England, 80.
J. Buchanan.—Ancient canoes found at Glasgow, 80.
J. A. Campbell.—Auriferous Quartz of Australia, 81.
W. Darling.—Probable maximum depth of the Ocean, 81.
J. W. Dawson.—Fossils of the Coal-formation of Nova Scotia, 81.
D. Forbes.—Silurian and Metamorphic rocks of the South of Norway, 82.
R. Harkness and J. Blyth.—Cleavage of the Devonians of the South of Ireland, 82.
R. Harkness.—Lowest Sedimentary rocks of Scotland, 82.
—— Geology of Dingle Promontory, Ireland, 83.
E. Hopkins.—Gold-bearing districts of the World, 83.
H. Miller.—Fossil Floras of Scotland, 83.
R. I. Murchison.—Crystalline fossiliferous rocks of the North Highlands, 85.
J. Nicol.—Striated rocks and other evidences of ice-action in the North of Scotland, 88.
D. Page.—Pterygotus and Pterygotus-beds of Britain, 89.
—— Burdiehouse Limestone, 91.
—— Palæozoic and Metamorphic rocks of Scotland, 92.
J. Phillips.—Trap-dykes in Arran, 94.
H. Poole.—Search for Coal in Asia Minor, 94.
J. W. Salter.—Fossils from the Longmynd, 95.
H. C. Sorby.—Structure and relations of the older rocks of the Highland Border, 96.
—— Mechanical Structure of Limestones, 97.
—— Effects of currents on deposits, 97.
W. S. Symonds.—Fossil Crustacea from Ludlow, 98.
S. V. Wood, Jun.—Probable maximum depth of the Ocean, 99.
E. Belcher.—Great fossil tree in the Arctic regions, 101.
A. and R. Schlagintweit.—Himalayas of Kumaon, 152.
W. Sim.—Blasting and quarrying of rocks, 209.
J. W. Salter.—Geology of the Arctic regions, 211.

Canadian Institute. Canadian Journal. New Series. No. 3. May 1856.

D. Wilson.—The ancient miners of Lake Superior, 225.

Canadian Institute. Canadian Journal. New Series (*continued*).

S. Fleming.—The Canadian Geological Survey and its Director Sir W. Logan, 238.
E. J. Chapman.—Trilobites, part 1, 271.
W. B. Rogers.—Origin of the Carbonate of Iron of the Coal-measures, 307.
R. Owen.—Fossil Musk-buffalo, 307.
Wœhler and Atkinson.—Graphite in Meteoric Stones, 308.
E. J. Chapman.—Wolfram, 308.
Wöhler.—Silicium, 310.
Peligot.—Uranium.

———. ———. ———. No. 5. September 1856.

E. A. Meredith.—Influence of recent gold-discoveries on prices, 430.
De Rottermund.—Exploration of Lakes Superior and Huron, 446.
Salter and Huxley.—Himantopterus from Lanarkshire, 482.
E. J. Chapman.—Asaphus Canadensis, 482.
Dufrenoysite; Binnite; Hyalophane; Rhodonite, 483.
Voigtite; Volknerite; Boronatrocalcite; Schaumkalk; Torbane-hill mineral, 484.

Chemical Society, Quarterly Journal. Vol. ix. No. 2. July 1856.

F. Field.—Analysis of a Meteoric Stone from the Desert of Atacama, 143.

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F. A. Abel.—Composition of some varieties of foreign iron, 202.

Civil Engineer and Architect's Journal. Vol. xix. No. 268. July 1856.

J. Wilson.—Tidal rivers, 235.

———. No. 269. August 1856.

T. Hopkins.—Oceanic currents, 269.
R. W. Mylne's Geological Map of London, noticed, 284.

———. No. 270. September 1856.

C. Daubeny.—Presidential Address, British Association, 289.
H. C. Sorby.—Magnesian limestone, drift-bedding, and mica-schist, 295.
H. Hennessy.—Inundations of rivers, 295.
H. C. Page.—Indurating stone, 314.

———. No. 271. October 1856.

Decay and preservation of stone-work, 330.
H. Hennessy.—Physical structure of the Earth, 335.
H. Bessemer.—Manufacture of Steel and Iron, 348 (plate).

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I. G. Forchhammer.—Iagttagelser over Metallerne i Kalkstenen, og i Havets kalkassondrende Dyr, 223.
——— Undersögelser over Metallerne i Havets Dyr og Planter, 389.
J. Steenstrup.—Bidrag til Danmarks forhistoriske Fauna, 1, 52.

Copenhagen. Oversigt over det Kong. danske Videnskab. Selskabs Forhandlinger og dets Medlemmers Arbeider i Aaret (*continued*).

J. Steenstrup.—Om Udbyttet af hans 1854 i Jylland foretagne Geologiske Antiquariske Undersögelser, 131.

—— Om Bæverens, Kjderskildpaddens og Geirfuglens tidlizere Forekomst i Danmark, 381.

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W. J. Henwood.—The rock-basins at Deo Dhovra in Upper India, 19.

Critic. Nos. 366–374. July–October 1856.

Notices of Meetings of Societies.

Dublin. Royal Irish Academy, Proceedings. Vol. vi. Part 3. 1855–56.

J. H. Jellett.—The effect of the internal fluidity of the Earth on the length of the day, 372.

H. Hennessy.—The influence of the Earth's internal structure on the length of the day, 388.

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R. Griffith.—The Moving Bog of Kilmaleady in King's County, 141 (map).

Edinburgh Royal Society, Proceedings. Vol. iii. No. 46.

A. A. Hayes.—Native Iron in Liberia, Africa, 327.

R. Chambers.—Geology of Banffshire, 332.

H. C. Sorby.—Physical Geography of the Old Red Sandstone Sea of the central district of Scotland, 334.

J. Forbes.—Geological relations of the Secondary and Primary Rocks of the Chain of Mont Blanc, 348.

W. Gregory.—Diatomaceous sand of Glenshira, part 2, 358.

H. James.—Deflection of the Plumb-line at Arthur's Seat, and the mean density of the Earth, 364.

H. D. Rogers.—Laws of structure of the more disturbed zones of the Earth's Crust, 378.

T. Bloxam and G. Wilson.—Analysis of Craigleith Sandstone, 390.

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H. D. Rogers.—On the Laws of Structure of the more disturbed zones of the Earth's Crust, 431.

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France. Société Géologique, Bulletin. Deux. Sér. Tome xii. Feuill. 61–65.

De Tchihatchef.—Lettre sur l'éruption de Vesuve en mai 1855, 962.

Ch. S.-C. Deville.—Lettre sur le même sujet, 963.

De Verneuil et Barrande.—Description des fossiles trouvés dans les terrains silurien et devonien d'Almaden, d'une partie de la Sierra Morena et des montagnes de Tolède (Pl. xxiii. à xxix.), 964.

France. Société Géologique, Bulletin. Deux. Sér. (*continued*).

Benoît.—Note sur le terrain sidérolithique des environs de Montbéliard (Pl. xxx.), 1025.

Sterry Hunt.—Observations sur les roches magnésiennes du groupe de la rivière Hudson, 1029.

Th. Ébray.—Note sur les Spongiaires des environs de Vierzon, 1032.

J. Fournet.—Sur des gîtes d'oxyde d'antimoine du pays des Haractas (Algérie), 1039.

Marie Rouault.—Notice sur quelques espèces du terrain dévonien du nord du département de la Manche, 1040.

———. ———. ———. Tome xiii. Feuill. 8–14.

Marcel de Serres.—Sur les silex taillés trouvés dans les dépôts diluviens, 113.

Th. Ébray.—Étude comparative des *Ammonites anceps* et *pustulatus*, 115.

Triger.—Observations sur les sables des environs de Nogent-le-Rotrou (Eure-et-Loir) (Pl. vii.), 118.

François Lanza.—Essai sur les formations géognostiques de la Dalmatie et sur quelques nouvelles espèces de Radiolites et d'Hippurites (Pl. viii.), 127.

E. Bayle.—Observations sur le *Radiolites cornu-pastoris*, Desmoulin, sp. (Pl. ix.), 139.

B. Studer.—Notice sur le terrain anthracifère dans les Alpes de la Suisse, 146.

A. Langel.—Présentation d'un globe terrestre avec le réseau pentagonal de M. Élie de Beaumont, 163.

Griffith.—Lettre accompagnant l'envoi de sa carte géologique de l'Irlande, 164.

Marcel de Serres.—Des ossements humains des cavernes et de l'époque de leur dépôt (Résumé), 169.

V. Raulin.—Observations sur le *Résumé d'un essai sur la géologie des Corbières* par M. d'Archiac, 170.

D'Archiac.—Remarques sur les observations précédentes, 173.

J. Desnoyers.—Réponse aux observations de M. Triger sur les sables des environs de Nogent-le-Rotrou (p. 118), 177.

Argéliez.—Lettre sur une collection de fossiles du département de l'Aveyron, 187.

Ed. Piette.—Notice sur les grès d'Aiglemont et de Rimogne (Pl. x.), 189.

Ed. Hébert.—Note sur le lias inférieur des Ardennes, suivie de remarques sur les Gryphées du lias, 207.

Michelin.—Sur deux échinides des couches supracrétacées de la Jamaïque, 222.

G. Jenzsch.—Note supplémentaire sur l'amygdalophyre, 222.

———. ———. Tome xiii. Feuill. 15–19.

G. Jenzsch.—Note supplémentaire sur l'amygdalophyre (fin.), 225.

L. Cocchi.—Description des roches ignées et sédimentaires de la Toscane (Pl. xi.), 226.

Shumard.—Sur la paléontologie du Missouri, 302.

Feuardent.—Sur quelques fossiles de la montagne du Roule (Manche), 302.

———. ———. Liste des Membres au 1er Mai 1856.

Franklin Institute of Pennsylvania, Journal. 3rd Series. Vol. xxxi. No. 6. June 1856.

H. Clarke.—Slag-bricks, 410.

———. ———. Vol. xxxii. No. 1. July 1856.

———. ———. ———. No. 2. August 1856.

———. ———. ———. No. 3. September 1856.

C. Stickel.—Basaltic glass, 183.

W. H. Pile.—Specific gravity of sea-water.

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C. J. Andrae.—Fossile Pflanzen der Tertiärformation der Szakadat und Thalheim in Siebenbürgen und der Liasformation von Steindorf im Banat, 201.

C. Giebel.—Crinoideen im Kreidemergel bei Quedlinburg, 25 (plate).

C. J. Andrae.—Zwei Fruchtarten aus der Steinkohlenformation Saarbrücken, 43.

C. Giebel.—Ueber der Myophorien des Muschelkalkes, 34.

E. Söchting.—Mineralogisch-paläontologische Notizen, 370.

Literature: General, Mineralogy, Geology, Paleontology.

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C. Giebel.—Erdbeben in Wallis vom 25 Juli bis 7 August 1855, 1.

E. Söchting.—Mineralogische Notizen, 361.

G. Suckow.—Zur Geologie und Mineralogie [Central heat: minerals, genetic and metamorphic: Chlorite in Bunter], 261.

C. Giebel.—Ausflug in die Walliser Alpen, 39.

— Wirbelthierreste in der Thüringer Braunkohle, 204.

A. Schmit.—Asterien im Lias bei Halberstadt, 203.

E. Söchting.—Reise in England und Schottland, 378.

Literature: General, Mineralogy, Geology, Palæontology.

Harlem. Extrait du programme de la Société Hollandaise des Sciences à, pour l'année 1856.

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Lausanne. Bulletins des Séances de la Société Vaudoise des Sciences Naturelles. Tome i., années 1842–45. 1846.
Béranger.—Un fossile végétal, 92.
Blanchet.—Les houillères d'Oron, 186.
—— Altitudes dans le Canton, 200.
—— La distribution des dépôts erratiques dans le bassin du Léman, 258.
—— Une mâchoire de rhinocéros, 278.
—— Un os du *Mylodon robustus*, 337.
—— Les variétés de poli des roches, 358.
—— La mine de houille de Pully, 358.
Colomb.—La Dent de Jaman, 358.
De la Harpe.—Un bloc de gypse erratique, 208, 337.
Desor.—Les phénomènes erratiques, 270.
Lardy.—La géologie du Jura Vaudois, 345.
Wartmann.—L'application de deux théorèmes de géométrie élémentaire à l'explication de certains phénomènes géologiques, 395.

———. ———. Nos. 10 and 11. 1846.

———. ———. No. 34. 1854.
R. Blanchet.—Sur les modifications du relief de la terre dans le vallée du Rhône et du Léman, 157.
S. Chavannes.—Sur un ancien lit de la Morge, 161.
Nicaty.—Sur un bloc erratique d'une grande dimension, existant dans le ravin de l'Aubonne, 174.

———. ———. No. 35. 1855.
E. Renevier.—Notice sur l'ouvrage intitulé Description Géologique des Environs de Montpellier, par P. G. de Ronville, 181.
—— Sur la classification des Terrains Crétacés, 191.
Ph. Delaharpe.—Ossemens appartenant à l'*Anthracotherium magnum*, recueillis dans les lignites des environs de Lausanne, 175.
E. Renevier.—Seconde note sur la géologie des Alpes Vaudoises, 204.
R. Blanchet et Lecoultre.—Sur les effets du gel au lac de Joux, 224 (map).
Burnier, C. Dufour, et Yertin.—Sur la temperature de quelques sources d'eau, 226.
Ph. Delaharpe.—De la formation sidérolitique dans les Alpes, 232.

———. ———. No. 36. 1855.
Ph. Delaharpe et E. Renevier.—Excursion géologique à la Dent-du-Midi (Bas-Valais), 261 (plate).
E. Renevier.—Sur le terrain rhodanien situé près de Montalban, 280.

Lausanne. Bulletins des Séances de la Société Vaudoise des Sciences Naturelles (*continued*).

Ph. Delaharpe.—Sur des os de Castor ancien, 301.

—— Houille Kimmeridgienne du Bas-Valas, 304.

S. Chavannes.—Sur le terrain sidérolitique de la Colline Néocomienne de Chamblon près Yverdon, 310.

Bischoff.—Analyse d'un Jayet provenant de la Molasse, près d'Yverdon, 317.

E. Renevier.—Dates de la publication des espèces contenues dans les planches de la Conchyliologie minéralogique de la Grande-Bretagne, par Mr. James Sowerby, continuée par James de Carle Sowerby, 318.

R. Blanchet.—Sur la flore fossile du terrain anthracifère des Alpes, 322.

S. Chavannes.—Sur la coupe d'un dépôt d'alluvion, près Renens, Environs de Lausanne, 324.

———. ———. No. 37. 1856.

Ph. Delaharpe et C. T. Gaudin.—Flore fossile des Environs de Lausanne, 347, 422.

E. Renevier.—Résumé des travaux de Mr. D. Sharpe sur le clivage et la foliation des roches, 379.

C. T. Gaudin et Ph. Delaharpe.—Sur les brêches à ossements éocènes du terrain sidérolitique du Maurement, 402.

C. Nicartz.—Sur le desséchement du lac de Harlem en Hollande, 404.

A. Yertin.—Sur les seiches du lac Léman, 411 (plate).

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The Mines of Wicklow, 776.

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Notices of Meetings of Societies; and Obituary Notices.

Liverpool Literary and Philosophical Society, Proceedings. No. 10. 1855–56.

G. H. Morton.—Subdivisions of the New Red Sandstone of part of Cheshire, 68 (2 plates).

E. Bretherton.—Geological ramble, 148.

London, Edinburgh, and Dublin Philosophical Magazine. 4th Series. No. 75. Supplement, July 1856.

From R. Taylor, Esq., F.G.S.

J. W. Tayler.—Cryolite of Greenland, 551.

D. T. Ansted.—Copper-lodes in Cuba, 552.

———. ———. No. 76. July 1856.

H. M. Witt.—Separation of mineral salts from water by filtration, 23.

J. Tyndall. Cleavage of crystals and slates, 35.

London, Edinburgh, and Dublin Philosophical Magazine. No. 76 (*continued*).

S. Haughton.—Density of the Earth, deduced from the experiments in Harton Coal-pit, 50.
J. C. Moore.—Silurian rocks of Wigtonshire, 68.
C. Babbage.—Action of ocean-currents in the formation of the strata of the Earth, 69.
J. Plant.—Keuper sandstone of Leicester, 71.
P. B. Brodie.—Keuper sandstone of Warwickshire, 71.
J. W. Salter.—Diploceras, 72.
S. P. Woodward.—Orthoceras from China, 72.
W. S. Symonds.—Trap-dykes in the Malverns, 73.
J. G. Sawkins.—Movement of land in the South Sea Islands, 73.
L. B. Ibbetson.—Origin of gold-veins, 73.

———. ———. No. 77. August 1856.

H. Hennessy.—Influence of the Earth's internal structure on the length of the day, 99.
H. M. Witt.—Chemical composition of the Thames water, 114.
H. J. Brooke.—Bleiniere, 126.
H. C. Sorby, and J. Tyndall.—Slaty cleavage, 127, 129.
S. Charters.—Mont Lacha, 150.
W. Miller.—Mauna Loa, 150.
T. Spratt.—Geology of Varna, 150.
H. G. Bowen.—Geology of Trinidad, 151.
J. W. Salter and W. Bailey.—Cretaceous fossils from Aberdeenshire, 152.
J. Prestwich.—Correlation of the Middle Tertiaries of England, France, and Belgium, 153.

———. ———. No. 78. September 1856.

J. F. W. Herschel.—Slaty cleavage and contortions of rocks, 197.
G. B. Airy.—Experiments in the Harton Colliery shaft for determining the mean density of the Earth, 228.
Hautefeuille.—Mercury in the native argentiferous copper of Lake Superior, 238.

———. ———. No. 79. October 1856.

H. James.—Mean specific gravity of the Earth, 314.

Longman's Monthly List of New Books. N. S. Nos. 163 and 166.

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W. Gregory.—Post-tertiary Diatomaceous Sands of Glenshira, Part 2, 67 (plate).

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Paris. Académie des Sciences. Comptes Rendus. Tome xli. Parts 13–27.

M. de Serres.—Des caractères et de l'ancienneté de la période quaternaire, 488.

R. Greg et Dr. Heddle.—Sur une masse de fer météorique renfermant des globules de plomb métallique, 490.

A. Bineau.—Études chimiques sur une partie des eaux du bassin du Rhône, 511.

F. Pisani.—Analyse de l'eau du Bosphore, prise à Bujuk-Déré, près l'embouchure de la mer Noire, 532.

A. Poey.—Sur la force ascensionelle qu'exercent les ouragans à la surface du sol, comme pouvant donner lieu à la production des tremblements de terre, 585.

C. Sainte-Claire Deville.—Quatrième Lettre sur l'éruption du Vésuve du 1er mai, 1855, 593.

H. Soleil.—Note sur un moyen nouveau de reconnaitre si les faces parallèles entre elles d'une plaque de cristal de roche sont aussi parallèles à l'axe du cristal ou inclinées sur cet axe, 669.

E. Filhol.—Nouvelles recherches sur les eaux minérales des Pyrénées, 693.

— Ville.—Notice sur les gîtes d'émeraudes de la haute vallée de l'Harrach, 698.

A. Poey.—Tableau chronologique des ouragans cycloniques qui ont eu lieu aux Indes occidentales et dans le nord de l'Atlantique, dans une période de 372 années, de 1493 à 1855, 701.

A. Valenciennes.—Observations sur des Oursins perforants dans le granite de Bretagne, 755.

C. Prévost.—Étude des phénomènes volcaniques du Vésuve et de l'Etna, 794.

—— Considérations générales et questions sur les éruptions volcaniques, 866.

—— Sur la théorie des cônes et des cratères de soulèvement, 919.

E. Collomb.—Sur les tremblements de terre du Valais, 952.

D'Hombres Firmas.—Description de deux coquilles fossiles nouvelles ou nouvellement observeés, 1083.

A. Damour.—Sur un péridot titanifère de Pfunders, en Tyrol, 1151.

Fontan.—Sur le tremblement du terre du 5 décembre, 1855, 1158.

J. Bouis.—Recherches sur les produits azotées des eaux thermales sulfureuses, 1161.

J. Niklès.—Présence de la vivianite dans les ossements humains, 1169.

———. ———. Vol. xlii. Parts 1–26.

P. Verollot.—Tableaux des tremblements de terre qui ont eu lieu dans l'Empire Ottoman en 1855, 93.

E. de Beaumont.—Sur une carte géologique de la province Rhénane et de la province de Westphalie, par von Dechen, 100.

A. Perrey.—Sur des volcans et solfatares de l'île de Java, 115.

A. Gaudry.—Sur l'exploitation du gîte fossilifère de Pikermi, 291.

Verollot.—Tableau des tremblements de terre éprouvés à Constantinople pendant 15 ans (1841–55), 293.

De Senarmont.—Sur la forme cristalline du silicium, 313.

Paris. Académie des Sciences. Comptes Rendus. Vol. xlii. Parts 1–26 (*continued*).

I. Geoffroy Saint-Hilaire.—Sur un œuf d'Epyornis, 315.
Alphand.—Sur le puits artésien de Passy, 332.
F. de Francq.—De la formation et de la répartition des reliefs terrestres, p. 378.
A. Pissis.—Études sur l'orographie et sur la constitution géologique du Chili, 391.
—— Recherches sur les systèmes de soulèvement de l'Amérique du Sud, 392.
Ville.—Notice minéralogique sur le cercle de Laghonat, 396.
M. de Serres.—Sur la présence des zircons dans les sables marins tertiaires (pliocène) de Soret, dans les environs de Montpelier, 434.
Rotureau.—Sur les eaux thermales de Nauheim, 438.
Bertrand.—Sur un gisement de puozzolane dans la Haute-Loire, 550.
D'Hombres Firmas.—Observations sur le *Pecten glaber*, 612.
Meugy.—Sur le gisement, l'âge, et le mode de formation des terrains à meulières du bassin de Paris, 628.
A. Leymerie.—Du terrain jurassique dans les Pyrénées françaises, 730.
M. de Serres.—De l'époque géologique à laquelle on doit rapporter le dépôt des spinelles et des zircons dans les sables marins de Sauret, 827.
J. Durocher.—Études sur la production artificielle des minéraux et sur les conséquences qui en résultent pour la géologie, 850.
Boussingault.—Sur un gisement de platine signalé dans un filon de la province d'Antioquia, 917.
E. de Billey.—Note sur la carte géologique du département des Vosges, 963.
Rozet.—Moyens de forcer les torrents des montagnes à rendre à l'agriculture une partie du sol qu'ils ravagent, 991.
F. Fournet.—Aperçus relatifs à la théorie des gîtes métallifères, 1097.
L. L. Vallée.—Sur le lac de Genève à l'occasion des inondations de la vallée du Rhône, 1140.
Renaud.—Sur la constitution géologique de l'isthme de Suez, 1163.
C. Sainte-Claire Deville.—Sur les produits des volcans de l'Italie méridionale, 1167.
L. L. Vallée.—Sur la réserve du lac de Genève, 1181.
Vigat.—Sur l'action saline de l'eau de mer sur les composés hydrauliques en général, 1200.
Rozet.—Sur la grande inondation de la Loire, 1204.
Delesse.—Carte hydrographique souterraine de la ville de Paris, 1207.
Boussingault.—Sur les variations que l'eau de la mer Morte semble subir dans sa composition, 1230.
Dausse.—Note relative aux inondations, 1241.
J. Durocher.—Sur les gîtes métallifères, et sur la disposition relative des cristaux de quartz et de feldspath dans les roches granitiques, 1251.
Rozet.—Sur le puits foré de Tamerna, 1258.
J. Bouis.—Sur la présence de l'ammoniaque dans certaines eaux minérales, 1269.

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———. ———. Vol. viii. Part 4. 1856.

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J. Leidy.—*Bathygnathus borealis,* 327 (plate).

———. ———. Proceedings. Vol. vi. No. 7.

C. M. Wetherill. Melan-asphalte from Hillsborough, New Brunswick, 225.

Leidy.—Fossil mammalian teeth, 241.

F. V. Greene.—Chemical investigation of fossil mammalian remains, 292.

F. A. Genth.—New variety of grey copper, 296.

—— Owenite, 297.

———. ———. ———. No. 8.

Leidy.—Ursus and Megalonyx at Natchez, Mississippi, 303.

T. A. Conrad.—Monograph of genus Fulgur, 316.

—— Dreissena, Artemis, Acanthina, &c., 320.

———. ———. ———. No. 9.

———. ———. ———. No. 10.

Leidy.—Fossil Cetacea from the Greensand of New Jersey, 377.

D. D. Owen and F. A. Genth.—Saponite, 379.

Leidy.—Fossil Mammals and Chelonians from Nebraska, 392.

———. ———. ———. No. 11.

———. ———. ———. No. 12. Title-page and Index.

C. M. Wetherill.—Iron and titanium, 434.

T. A. Conrad.—Cassidula and Athleta, 448.

———. ———. ———. Vol. vii. No. 1.

A. T. King.—Ancient alluvium of the Ohio and its tributaries, 4.

Photographic Society, Journal. Nos. 44, 45, 46, 47.

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F. W. Beechey.—Anniversary Address, and Obituary Notices.

Royal Institution of Great Britain, List of Members, &c., for 1855–1856.

———. Notices of Meetings. Part vi. 1855–56.

J. Barlow.—Aluminium, 213.

C. Lyell.—Successive changes of the Temple of Serapis, 207.

R. Owen.—Ruminants and the aboriginal cattle of Britain, 256.

H. D. Rogers.—Geology and Physical Geography of North America, 167.

J. Tyndall.—Cleavage of crystals and of slate-rocks, 295.

Royal Society, List of Fellows. 1855.

———, Proceedings. Vol. viii. No. 21.

H. James and others.—Figure, dimensions, and mean specific gravity of the Earth, as derived from the Trigonometrical Survey of Great Britain and Ireland, 111.

———. ———. No. 22.

H. J. Brooke.—Geometrical isomorphism of crystals, 187.
W. B. Carpenter.—Foraminifera, part 2, 205.

———, Transactions. Vol. cxlv. 1855.

Pratt, J. H.—On the attraction of the Himalaya Mountains, and of the elevated regions beyond them upon the plumb-line in India, 53.
Airy, G. B.—On the computation of the effect of the attraction of mountain-masses as disturbing the apparent astronomical latitude of stations in geodetic surveys, 101.
Horner, L.—An account of some recent researches near Cairo, undertaken with the view of throwing light upon the geological history of the alluvial land of Egypt, 105.
Hooker, J. D., and E. W. Binney.—On the structure of certain limestone-nodules enclosed in seams of bituminous coal, with a description of some Trigonocarpons contained in them, 149.
Owen, R.—On the Megatherium.

———, ———. Vol. cxlvi. Part 1. 1856.

J. H. Pratt.—On the effect of local attraction upon the plumb-line at stations on the English arc of the meridian, between Dunnose and Burleigh Moor, 31.
W. B. Carpenter.—Researches on the Foraminifera, 181.
W. J. Rankine.—On axes of elasticity and crystalline forms, 261.
G. B. Airy.—Account of pendulum experiments undertaken in the Harton Colliery, for the purpose of determining the mean density of the Earth, 297.

Society of Arts, Journal. Nos. 191–207.

Exports and imports in the United Kingdom of Copper, Zinc, Tin, and Lead, 602.
J. B. Daines.—Decay and preservation of stone-work, 604, 629.
A. E. Bruckmann.—Absorbent bored wells, 609, 621, 634, 645.
D. Mushet.—Iron-ores of Great Britain, 617.
Induration of stone, 630.
D. T. Ansted.—Absorbing wells, 643.
H. Clarke.—Absorbing wells, 655.
J. B. Denton.—Absorbing wells, 668.
E. C. Lewis.—Lithographic stone in Jamaica, 684.
Bessemer's manufacture of iron, 695, 708, 714.
H. H. Burnell.—Decay and preservation of stone-work, 713.
Bessemer's manufacture of iron, 758.
A. E. Bruckmann.—Absorbent bored wells, 764.
Booth.—Address, What to learn, 768.
H. W. Reveley.—Inundation and natural river-drainage, 786.
— Hydraulic cement, 788.

Statistical Society, Journal. Vol. xix. Part 3. September 1856.

R. Hunt.—Present state of the mining industries of the United Kingdom, 201.

Stockholm. Års-berättelse om botaniska arbeten och upptäckter för år 1851 till kongl. Vetensk.-Akad. afgifven den 31 Mars 1852. Af J. E. Wikström. 1855.

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Erdmann.—Utö jernmalmsfälts geologiska betkaffenhet, 141.
—— Om de gamla vattenmärkena vid Södra Stäket, 329 (plate).

Stuttgart. Württembergische naturwissenschaftliche Jahreshefte. Erster Jahrgang. 1845. Parts 1 & 2.

Quenstedt.—Ueber Hoffnung auf Kohlen in Württemburg, 145.
Sigwart.—Ueber die Canstatter und Berger Mineralquellen, 150.
Mandeleslohe.—Ueber *Palæomeryx Scheuchzeri* und *Gyrodus umbilicus*, 152 (plate).
G. Leube.—Ueber die Bedeutung der Chemie für die Geognosie, 153.
Zenneck.—Ueber die Gaze, 154.
Kurr.—Ueber einige weniger bekannte Gebirgsarten des Schwarzwaldes, 155 (pl. 2, figs. 3, 4).
Plieninger.—Ueber den englischen hydraulischen Cement und das Vorkommen des Gesteins in Württemberg, 157.
—— Ueber *Tubifex antiquus*, 159 (pl. 2, fig. 5).
Von Seyffer.—Beschreibung des Diluviums im Thale von Stuttgart und Canstatt, 183 (map).
Kurr.—Ueber einige Belemniten Württembergs, 233.
F. Krauss.—Backenzähne von Palæomeryx, 255.

———. ———. Zweiter Jahrg. 1846. Parts 1–3.

Von Klein.—Conchylien der Süsswasserkalkformationen Württemberg's, 60 (2 plates).
Plieninger.—Ueber ein neues Sauriergenus und die Einreihung der Saurier mit flachen, schneidenden Zähnen in eine Familie, 148, 247 (plate).
Quenstedt.—Ueber die Mineralien in den Luftkammern der Cephalopoden, 154.
G. Leube.—Ueber die Bildung des Grundeises, 165.
Sigwart.—Ueber hydraulischen Kalk, 168.
Kurr und Quenstedt.—Ueber Wahrscheinlichkeit des Vorkommens von Steinkohlen in Württemberg, 170.
Rampold.—Ueber den See der einst das Neckarthal bei Canstatt bedeckte, und über das Verhalten der Canstatten Mineralquellen zu einander, 188.
Ch. Paulus.—Ueber ein Vorkommen von Mergelkrystallen in der Keuperformation, 196.
Fraas.—Die Thone des unteren Lias, 202 (pl. 3, fig. 3).
Fehling.—Ueber das Vorkommen des Titans in Eisenschlacken, 255.
Rogg.—Hypsometrische Tafel, für die orographischen und geographischen Verhältnisse Schwabens eingerichtet, 368.

Stuttgart. Württembergische naturwissenschaftliche Jahreshefte. Zweiter Jahrg. (*continued*).

Ch. L. Landbeck.—Ueber das niederfallen eines Meteorsteines, 383 (plate).

———. ———. Dritten Jahrg. 1847. Parts 1–3.

Fehling.—Analyse einiger Ofenbrüche aus dem Hochofen zu Ludwigsthal bei Tuttlingen, 133.

Schlossberger.—Arsenik im Canstatter Mineral-wasser-schlamm, 151.

Sigwart.—Brom im Wasser von Friedrichshall und Canstatt, 152.

Plieninger.—Cyprinoiden-Zähne im Süsswasserkalk von Steinheim, 162 (pl. 1, figs. 1, 2).

—— *Microlestes antiquus* und *Sargodon tomicus* in der Grenzbreccie von Degerloch, 164 (pl. 1, figs. 3–10).

H. v. Meyer.—*Palæochelys bussenensis* im ältern Süsswasserkalk, 167 (pl. 1, fig. 11).

Fraas.—Die Loben der Ammoniten, 169 (pl. 2).

Jäger.—Ueber Geröllebildung, 172.

—— Ueber *Bos Bison* und *Bos urus*, 176.

Weissman.—Crailsheimer Petrefactenverzeichniss, 191.

Th. Fraas.—Orthoceratiten und Lituiten im mittleren schwarzen Jura, 218 (pl. 1, figs. 12–14).

A. Ducke.—Beschreibung des Mineralwassers des Krumbach-Mühle-Bades zwischen Wolfegg und Kisslegg, 223.

Th. Plieninger.—Die Wirbelthierreste im Korallenkalk von Schnaitheim, 226 (pl. 1, fig. 15).

Nekrolog Major v. Zieten's, 249.

Th. Plieninger.—*Anoplotherium commune* im ältern Süsswasserkalk, 261.

—— Knochenführender Diluvium im Gebiete der Molasse, 261.

—— Ein nicht fossiles Nagethier im Muschelkalk, 262 (pl. 1, fig. 20).

———. ———. Vierter Jahrg. 1848. Parts 1–3.

Kurr.—Zur Geologie der Triasformation im Württemberg und des Steinsalzes im Besonderen, 1.

H. Fehling.—Chemische Untersuchung der Soolen, des Koch- und Stein-salzes und der Siedeabfälle der K. Württembergischen Salinen, 18.

Quenstedt.—Ueber die Gränzen der Muschelkalkformation, 57.

Schlossberger.—Küpfergehalt einiger im Handel vorkommenden Oelkuchensorten, 90.

Hehl.—Anzeige der Palæozoologie von Dr. C. G. Giebel, 111.

Eser.—Das Petrefaktenlager bei Ober- und Unter-Kirchberg an der Iller im Oberamt-Laupheim, 258.

Sigwart.—Vorkommen des Brom's und Jod's in den Mineralwassern und Heilquellen Württembergs, 269.

Hehl.—Anzeige der Mineralogie von E. Fr. Glocker, 279.

———. ———. Fünfter Jahrg. 1849. Parts 1–3.

Fraas.—Vergleichung des Schwäbischen Jura mit dem Französischen und Englischen, 1.

Th. Schraam und H. Fehling.—Untersuchung der Kalksteine Württemberg's auf Alkalien und Phosphorsäure, 58.

Stuttgart. Württembergische naturwissenschaftliche Jahreshefte. Fünfter Jahrg. (*continued*).

G. Jäger.—Ueber einige aus Griechenland erhaltene fossile Knochen, 124.

—— Ueber die Ausfüllung der fossilen Knochen durch erdige oder krystallinische Substanzen, 126.

Th. Plieninger.—Ueber Amphicyon, 216 (pl. 1, figs. 8, 9).

—— Ueber *Geosaurus maximus*, 252 (pl. 1, fig. 7).

Mandelsloh und Fraas.—Ueber Stylolithen, 147 & 259 (pl. 1, figs. 1–6).

Ph. Roman.—Rhyncholithen im Württembergischen Jura, 260.

————. ————. Sechster Jahrg. 1850. Parts 1–3.

Th. Plieninger.—Ueber hydraulischen Cement, 124.

Quenstedt.—Ueber Hippotherium der Bohnenerze, 165.

—— Ueber Mecochirus im braunen Jura, bei Gammelshausen, und einige andere Krebze, 186.

Bruckmann.—Flora œningensis fossilis, 215.

Ed. Breuninger.—Die Zusammensetzung verschiedener Torfarten, 245.

————. ————. Siebenter Jahrg. 1851. Parts 1–3.

Fehling und Kurr.—Untersuchung verschiedener Württembergischer Kalksteine, 95.

G. Jäger.—Ueber die Ruhe und Bewegung des Wassers auf der Oberfläche der Erde in seinem verschiedenen Cohäsionzuständen und die Folgen, welche sich daraus für die Oekonomie deratur ergeben, 139.

Ueber die Fundorte fossiler Ueberreste von Säugethieren, insbesondere in Stuttgart und seiner Umgebung, 169.

F. R. Furch.—Analyse der Mineralquelle oberhalb Beinstein im Oberamt-Waiblingen, 181.

Anon.—Beschreibung des Kiesel-Aluminits von Kornwestheim, 189.

Kurr.—Ueber die Enstehung des Flötzgebirges, 247.

————. ————. Achter Jahrg. 1852. Parts 1 & 2.

O. Fraas.—Tertiäre Ablagerungen auf den Höhen der Württemb. Alpen, 56.

Faber.—Ueber den mittleren schwarzen Jura in der Gegend von Gmünd, 59.

Roman.—Schichtenfolgen im Juragebirge Schwabens, 61.

Müller.—Vorkommen des Vanadiums in der Württemb. Bohnerzen, 66.

Von Dürrich und E. Schwarz.—Geognostiche Terrain-Profile durch Württemberg, 69 (plate).

Weismann.—Organische Reste aus dem Crailsheimer Muschelkalk, 77.

Plieninger.—Ueber Stylolithen, Fährten und Rutschflächen, 78.

Von Jäger.—Dinornis-Knochen, 116.

Plieninger.—Belodon Plieningeri, 116.

F. Krauss.—Die Mollusken der Tertiär-Formation von Kirchberg an der Iller, 136 (plate).

Klein.—Conchylien der Süsswasserkalkformation Württembergs, 157 (plate).

O. Fraas.—Beiträge zu Palæotherium-Formation, 218 (2 plates).

A. E. Bruckmann.—Flora œningensis fossilis, 252.

Stuttgart. Württembergische naturwissenschaftliche Jahreshefte. Neunter Jahrg. 1853. Parts 1–3.

O. Fraas.—Nachträge zu den Fronstetter Palæotherien, 63.

Quenstedt.—Ueber die Fronstetter Fossilien, über Menschenzähne und über Stylolithen, 64.

F. von Alberti.—Die Bohnerze des Jura, ihre Beziehung zur Molasse und zu Gypsen von Paris, Aix und Hohenhoewen, 76.

G. Jäger.—Ueber Dinornis, 91.

O. Fraas.—Der Bergschlipf von Rathshausen, 112.

G. Jäger.—Ueber einige fossile Knochen und Zähne des Donauthals, 129 (2 plates).

Bruckmann.—Negative artesische Brunnen, 173 (plate).

Klein.—Conchylien des Süsswasserkalkformation Württembergs, 203 (plate).

Quenstedt.—Ueber einen Schnaitheimer Lepidotuskiefer, 361 (plate).

———. ————. Zehnter Jahrg. 1854. Parts 1 & 2.

Kurr.—Ueber das natürliche Vorkommen einiger schweren Metalle, 24.

Fleischer.—Ueber einige röhrenförmige Brauneisensteine, 24.

Eser.—Ueber Pflanzen- und Thier-überreste aus den plattenförmigen Jurakalk von Nusplingen im Bernerthal, 29.

A. Oppel.—Der mittlere Lias Schwabens, 39 (4 plates).

———. ————. Eilfter Jahrg. 1855. Parts 1 & 2.

Nekrologe von Bergrath Dr. Hehl und Inspector von Fleischmann, 57.

O. Fraas.—Beiträge zum obersten weissen Jura in Schwaben, 77 (plate.)

Von Fehling.—Bestimmung der Menge an festen Bestandtheilen in einem Brunnen Stuttgarts, 126.

—— Specifisches Gewicht und Zusammensetzung der Soole von Hall, 127.

———. ————. Zwölfter Jahrg. 1856. Parts 1 & 2.

O. Fraas.—Ueber die Ablagerung von Petrefakten im Jura, 43.

Von Buhler.—Ueber die Beziehungen der Stromgebiete und Wasserscheiden zu den Gebirgen, 47.

Fleischer.—Ueber Kalksinterbildung, 61.

Eser.—Petrefakten, 63.

A. Oppel.—Ueber einige Cephalopoden der Juraformation Württembergs, 104.

Quenstedt.—Ueber *Pentacrinites colligatus*, 108 (plate).

Von Fehling und Von Kurr.—Untersuchung fossiler Fischzähne von unbekannter Abstammung, 118.

A. Oppel.—Die Juraformation Englands, Frankreichs und des südwestlichen Deutschlands, 121.

Van Diemen's Land Royal Society, Papers and Proceedings. Vol. iii. Part 1. January 1855.

R. C. Gunn.—Encroachments of the Sea along the North Coast of Tasmania, 54.

Penny.—Combustible schist of the Mersey River, Tasmania, 108.

A. R. C. Selwyn.—Coal of Van Diemen's Land, 116 (plates).

Vienna. Almanach der kaiserlichen Akademie der Wissenschaften. Sechster Jahrgang. 1856.

F. X. W. Zippe.—Gold, Kupfer, Eisen, 135.

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A. E. Reuss.—Paläontologische Miscellen [Dodo, Chelone Benstedi, Lepidoderma (Eurypterus) Imhofi, and Reptilian teeth], 71 (7 plates).

M. Hörnes.—Ueber einige neue Gastropoden aus den östlichen Alpen, 173 (3 plates).

———. ———. ———. Vol. xi. 1856.

F. R. v. Hauer.—Ueber die Cephalopoden aus dem Lias der nordöstlichen Alpen, 1 (25 plates).

R. Richter.—Beitrag zur Paläontologie des Thüringer Waldes, 87 (3 plates).

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Unger.—Ueber einige Pflanzenreste im Thonmergel des Kohlenflötzes von Prevali, 28 (plate).

Zeuschner.—*Rhynchonella pachytheca*, 48 (2 plates).

Süss.—Ueber Meganteris, 51 (3 plates).

Sandberger.—Ueber den inneren Bau einiger rheinischen Brachiopoden, 102 (2 plates).

Haidinger.—Ein optisch-mineralogischer Aufschraube-Goniometer, 110.

Reuss.—Ueber Koprolithen im Rothliegenden Böhmens, 124.

Hlasiwetz.—Analyse des Sauerbrunnens und der Schwefelquelle zu Obladis in Tirol, 133.

———. ———. ———. Vol. xviii. Part 2.

Reuss.—Beitrag zur Charakteristik der Tertiärschisten des nördlichen und mittleren Deutschlands, 197 (12 plates).

Richter und Unger.—Die organischen Einschlüsse des Cypridinenschiefers des Thüringer Waldes, 392.

———. ———. ———. Vol. xix. Part 1.

Leydolt.—Ueber die Structur und Zusammensetzung der Krystalle des prismatischen Kalkhaloides, nebst einem Anhange über die Structur der Kalkigen Theile einiger wirbellosen Thiere, 10 (9 plates).

Zeuschner.—Geognostische Beschreibung des Liaskalkes in der Tatra und in den angrenzenden Gebirgen, 135 (2 plates).

———. ———. ———. Vol. xix. Part 2.

Strasky.—Analyse der Anthrazit-Kohle aus der Nähe von Rudolfstadt bei Budweis in Böhmen, 325.

Vienna. Sitzungsberichte der k. Akad. der Wissensch. Math.-Nat. Cl. (*continued*).

Neugeboren.—Ueber die Foraminiferen aus der Ordnung der Stichostegier von Ober-Lapugy, 333.

Haidinger.—Ueber Herrn von Dechen's neue geologische Karte vom Rheinland-Westphalen, 336.

Zepharovich.—Die Halbinsel Tihany im Plattensee und die nächste Umgebung von Füred, 339 (2 plates).

———. ———. ———. Vol. xx. Part 1.

Moser.—Ueber die Zusammensetzung des Nilschlammes, 9.

Hochstetter.—Ueber die Lage der Karlsbader Thermen in zwei parallelen Quellenzügen auf zwei parallelen Gebirgsspalten, 13 (plate).

Hauer.—Ueber die Gewinnung von Vanadin aus den Joachimsthaler Uranerzen, 37.

—— Ueber einige neue Verbindungen des Cadmiums, 40.

Hörnes.—Ueber Gastropoden aus der Trias der Alpen, 68.

Stur.—Ueber den Einfluss des Bodens auf die Vertheilung der Pflanzen, 71.

Wöhler.—Ueber das Meteoreisen von Toluca in Mexico, 217.

Stur.—Ueber die geologische Uebersichtskarte der Neogen-tertiären, Diluvial- und Alluvial-Ablagerungen im Gebiete der nordöstlichen Alpen, 274.

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R. Fresenius.—Die Mineralquellen zu Langenschwalbach, 1.

A. Dollfuss und C. Neubauer. Chemische Untersuchung einiger Schalsteine des Herzog. Nassau, 49.

G. Sandberger.—Das Leptometer, 83.

Kurze notiz über das Werk "Versteinerungen des Rheinischen Schichtensystems in Nassau," 85.

G. Sandberger.—*Clymenia subnautilina*, 127 (plate).

Portrait of Von Buch (frontispiece).

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W. Thorp.—Ironstones of the oolitic district of Yorkshire, 394.

H. Denny.—Contemporaneity of the Megaceros with Man, 400.

R. C. Carter.—New Boring-machine, 449.

Zoological Society of London, Proceedings. Nos. 299–309.

R. Owen.—Dinornis (part vii.), 54.

II. GEOLOGICAL CONTENTS OF PERIODICALS PURCHASED FOR THE LIBRARY.

Annals and Magazine of Natural History. 2nd Ser. Vol. xviii. No. 103. July 1856.

T. H. Huxley.—On the method of Palæontology, 43.

R. Owen.—The Ruminantia and the aboriginal cattle of Britain, 61.

———. ———. No. 104. August 1856.

J. Phillips's Manual of Geology, noticed, 159.

O. Heer.—On the probable origin of the organized beings now living in the Azores, Madeira, and the Canaries, 183.

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———. ———. No. 106. Oct. 1856.
W. B. Carpenter.—Foraminifera, 334.

Dunker und von Meyer's Palæontographica. Vol. iv. Part 6. 1856.
W. Dunker.—Ueber mehrere Pflanzreste aus dem Quadersandsteine von Blankenburg, 179 (4 plates).
G. Sandberger.—Beitrag zur vergleichenden Naturgeschichte lebender und vorweltlicher polythalamer Cephalopoden, 184 (plate).
C. H. G. von Heyden.—Reste von Insekten aus der Braunkohle von Salzhausen und Westerburg, 198 (2 plates).
G. Fresenius und H. von Meyer.—*Sphæria areolata* aus der Braunkohle der Wetterau, 202 (plates).

———. ———. Vol. vi. Part 1. 1856.
H. von Meyer.—Palæontographische Studien :—Saurier aus der Kreide-gruppe in Deutschland und der Schweiz, 3; *Thaumatosaurus ooliticus* aus dem Oolith von Neuffen, 14; Neuer Beitrag zur Kenntniss der fossilen Fische aus dem Tertiärthon von Unter-Kirchberg, 22; *Arionius servatus*, ein Meersäugethier der Molasse, 31; *Delphinus canaliculatus* aus der Molasse, 44; Schildkröten und Säugethiere aus der Braunkohle von Turnau in Steyermark, 50; *Trachyastris Lardyi* aus der Molasse der Schweiz, 56 (8 plates).

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R. Harkness.—Scalariform tissue in the Devonian strata of Ireland, 65 (plate).
A. Aytoun.—Geology of the Southern Concan, 67 (map).

———. ———. Vol. iv. No. 2. Oct. 1856.
J. Martin.—The Northern drift, 209.
W. S. Symonds.—The transition beds from the Upper Silurian into the Old Red, and from the Old Red into the Carboniferous rocks, 239.
W. B. Rogers.—Discovery of Paradoxides in the altered rocks of Massachusetts, 301.
R. Harkness and J. Blyth.—The Lignites of the Giant's Causeway, the Isle of Mull, and Bovey-Tracey, 304.
H. C. Sorby.—The terraces in the Valley of the Tay, north of Dunkeld, 317.
R. Owen.—*Stereognathus ooliticus* from the Stonesfield slate, 337.
—— *Dichodon cuspidatus* from the Isle of Wight and Hordwell, 338.
H. C. Sorby.—Magnesian limestone, 338.
W. S. Symonds.—Origin of the Haffield conglomerate, 339.
H. C. Sorby.—Microscopical structure of Mica-schist, 339.
J. S. Bowerbank.—Siliceous bodies in the Chalk, 339.
W. H. Bailey.—Fossils from the Crimea, 340.
C. Moore.—Skin and food of Ichthyosauri and Teleosauri, 343.
W. Bessemer.—Manufacture of iron and steel, 357.
Fontan.—Fossil Apes, 371.
J. D. Hooker.—Progressive development (fossil botany), 372.

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H. J. Burkart.—Ueber die Fundorte der bis jetzt bekannten Mexikanischen Meteoreisen-Massen, nebst Bemerkungen über den Ursprung und die Zusammensetzung der Aerolithe, 257 (plate).

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Letters; Notices of Books, Mineralogy, Geology, and Fossils.

———. ———. ———. Viertes Heft.

O. Dieffenbach.—Bemerkungen über den Mineral-Reichthum der Vereinten Staaten von Nord Amerika, 385.

F. Stifft.—Chemisch-analytische Untersuchung des Orthits von Weinheim in Baden, 395.

K. C. v. Leonhard.—Künstlichen Graphit (ein Bruchstück aus "Hutten-erzeugnisse als Stützpunkte geologischer Hypothesen"), 398.

Letters; Notices of Books, Mineralogy, Geology, and Fossils.

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THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 3, 1856.

J. G. Croker, M.D., the Rev. E. F. Witts, the Rev. E. Duke, H. Bevan, M.D., the Rev. J. B. P. Dennis, and P. D. Margesson, Capt. R.A., were elected Fellows.

The following communications were read :—

1. *On the* Volcanic Eruption *at* Hawaii *in* 1855–56. By F. A. Weld, Esq. In a Letter to Sir C. Lyell, V.P.G.S.

You have done me the honour to say that any notes I could furnish concerning my visit to the Hawaiian volcanos, during the great eruption of 1855–56, would be of interest; unfortunately they can be only the reminiscences of an observer, not the researches of a scientific man; but, such as they are, I place them at your service.

I landed in the Sandwich Islands in October 1855, with the Hon. J. F. Stuart Wortley, in the island of Maui; and, hearing of the great eruption of Mauna Loa on the Island of Hawaii, we lost no time in proceeding thither by the earliest opportunity that offered itself. * * * * *

On the north-eastern coast, gradually rising from the clumps of cocoa-nut palms on the beach, sloping tracts of light-red volcanic soil and scoriæ, intersected by ravines, and partially covered with grass and wild indigo, led the eye up to the forests that clothe the mountain-sides. Three principal summits, Mauna Kea (13,800 ft.), Mauna Loa (the "Great Mountain," 13,700 ft.), and Mauna Hualalei (10,000 ft.), rose above the forests and upland-valleys, not, however, with that sharp-cut rugged angularity of form usual in volcanic regions, but rather rounded and swelling in their outline. Mauna Loa, almost in the centre of the island, appeared, from its size and distance, perfectly smooth and gently rounded. A little below its summit, two jets of smoke marked the craters of the recent eruption. The whole view was imposing, calm, and grand.

We crossed the island by the open upland-valley of the Waimea, where many of the products of the temperate zone flourish, and, passing over the shoulder of Mauna Kea amid forests and belts of timber, thence descended into the Hamakua district, and pursued our way towards the little town of Hilo, following a tract above the eastern sea-coast through a most beautiful country. Numerous ravines, filled with banana, bread-fruit, and candlenut trees, cut deeply through the grassy slopes, which, dotted with clumps of pandanus and bamboo, and varied by occasional small coffee and sugar plantations, rose from the sea-cliffs to the forests. As we approached Hilo, clear bright rivulets dashed down the rocky channels of the ravines and fell in cascades into the sea.

Hilo, a small town of cottages scattered among cocoa-nut, bread-fruit, and other trees along the shore of Byron's Bay, is a place of some importance as a resort of whalers, who frequent it for supplies. It may be said to stand at the foot of Mauna Loa, though the summit of the mountain is about forty miles inland, with a gradual ascent the whole way.

The three great mountains of Hawaii are all recent volcanos. Mauna Kea, the most northerly of the three, is somewhat the highest. Its summit bears evident traces of volcanic activity at no remote period; but of late years it has not been in eruption. Mauna Hualalei, on the west coast, was in eruption a few years ago. By far the most active is Mauna Loa. Kilauea, the largest active volcanic crater in the world, is situated on its acclivity, and is constantly active; whilst, above it, Mauna Loa proper presents an immense bare area, perhaps forty miles in diameter, which is entirely composed of volcanic debris and lavas of different ages; and few years pass by without its bursting forth in one direction or another.

On the 11th of August 1855, the present eruption burst forth at about 12,000 feet above the sea-level on the northern side of the mountain. It was rather remarkable for the enormous and unprecedented flow of lava than for any projection of inflamed substances into the air, though its light illumined the horizon for many miles, and the column of fire, or its reflexion, was said by some to have been at first apparently 500 feet high. At the commencement, the lava ran with great rapidity into the upland-valley that divides the summit of Mauna Loa from that of Mauna Kea; then, taking an easterly direction, it flowed down towards Hilo. The main branch was in many parts about three miles wide; but, as it reached comparatively level country, with forests, jungles, swamps, and streams, it spread to a width of five or six miles, and flowed more slowly. At the time we left Hawaii (Nov. 23, 1855) it had been gaining about a mile a week; but during the last week it had made yet more sensible progress. The whole length of the course of the lava was, including sinuosities, then computed at considerably more than fifty miles from the craters, and it was then only eight miles in a direct line from the town, which it threatened with destruction.

Our first good view from Hilo of the eruption was at night, from the deck of a ship in the harbour, as trees obstructed the view from the shore. The distant craters were scarcely visible; but the burning forests above Hilo showed the front of the advancing lava, lighting up the night with a mighty glare, with sometimes a column of red light shooting up, occasioned probably by an explosion of the half-cooled upper crust of lava, or by dried trees falling into the devouring element.

Having spent some days at Hilo, and completed the necessary arrangements, we started with natives and horses to Kilauea, intending to proceed thence on foot. The ascent, though very gradual, may be said to commence immediately on leaving Hilo. The weather was unpropitious, and, where the path was not old lava, it was deep mud; so that it was not until the second afternoon that we reached Kilauea, as we could hardly get our horses along. The country varied between woods and jungles* and open tracts of Fern, "Ti" (*Dracæna terminalis*), and other bushes. A little before we reached Kilauea, we entered the region of the "Koa,"—a tree resembling the Australian gums or *Eucalypti*, but which is, I believe, classed by Douglas as an *Acacia*. We also remarked a very handsome yellow Acacia, the Wild Strawberry and Raspberry, and some Tree-ferns. The soil, of a red colour, was covered with masses of scoriæ, and in many places entirely hidden by streams of old lava.

Our course from Hilo had been about thirty or thirty-five miles, its direction being nearly south by west, and latterly more westerly, when, on the afternoon of Nov. 14, we stood above the great crater of Kilauea, 4104 feet above the sea. We found a grass-built hut on the verge of the upper rim of the crater, and here we took up our quarters. The mountain of Kilauea may be described as the base of a broad, low, truncated cone, standing on a high level plateau on the side of Mauna Loa. It appears as if the apex had subsided, leaving in the centre of the mountain a flat sunken crater, the upper rim of which is about seven miles in circumference. Indeed, even now the level of the bottom of the crater is often lowered by eruptions.

In the year 1840 an underground eruption of Kilauea reduced the level of its crater 60 feet. The subterranean course of the lava was marked by steam-jets, until some miles below Kilauea it burst forth and ran with great rapidity, reaching the sea more than thirty miles off, in the Puna district, to the southward of Hilo, where it formed

* Chiefly of a tree of the Myrtle species, often covered with parasites, and bearing red and sometimes yellow flowers.

two or three islands. The sea was heated for many miles, and immense numbers of fish were killed.

From our hut we looked down upon two partially sunken ledges (covered with grass, fern, and bushes), which, as well as the spot where our hut stood, were in many places steaming. In one spot especially we remarked a large bank or mound composed apparently of a chalky substance, probably a deposit of some chemical salts, with a great deal of sulphur, from which issued a considerable body of steam. Below these ledges lay the great crater, like a round basin, about seven miles in circumference at the upper rim. The depth from the top of the highest of the surrounding cliffs to the bottom of the crater has been calculated at 1500 feet, though in many parts it is considerably less. These cliffs form a kind of wall of yellowish gravelly clay and dark basaltic rock, and are nearly perpendicular. The bottom of the crater is constantly changing. I was assured that there is often a lake of molten lava, a mile in length by half a mile in breadth. When we saw it, however, the crater was not in a very active state, and no such lake of fire was visible. Looking down into the crater, it had the appearance of a flat plain of dull lead-coloured lava, more or less broken and rugged in places, and containing an infinity of small mounds and craters, whence issued clouds of smoke, especially towards evening. As night came on, the action of the volcano appeared to increase, and the light of subterraneous fires was seen at many places; for Mr. Stuart Wortley, who was prevented by indisposition from proceeding with me to Mauna Loa, and remained at Kilauea until my return, observed some of the small craters within the great crater occasionally ejecting hot stones and melted lava; and on the night of my return from Mauna Loa I noticed the same thing on a small scale. I may here mention that, after my return from Mauna Loa, we descended into the crater of Kilauea, and spent some time in it. Its floor is evidently the cooled upper crust of fused lava. The numerous small mounds, or miniature craters, have orifices like the mouth of a limekiln, often double, in the side and on the summit, through which you may look into the red-hot depths below and caverns of subterraneous fire. We also remarked, in places, long ridges of smoking masses and fragments of rock that had evidently been upheaved through the lava-pavement, and piled confusedly on one another. The lava itself, on which we walked, was sometimes very hot, especially near the steam-vents and open abysses. The exhalations of sulphuric acid and other noxious gases were also in places an impediment to our explorations. The lava is generally of a dull glossy lead-colour, when quite cool; but of a brighter green or blue, when more recent. It cools into every variety of form and consistency; the most curious is the capillary lava, called by the natives "Pelé's hair." It strongly resembles hair of reddish, brownish, or golden hues; and is supposed by the Sandwich Islanders to be the hair of the goddess Pelé, who luxuriates in the bath of fire of her volcanos, as they do in the cool waves that break over their coral-reefs.

Having spent a night in the grass-hut above the crater of Kilauea, I started early in the morning of Nov. 15, with three natives, to the new craters on Mauna Loa. After walking a couple of miles over grass-country, we entered a wood, and commenced the ascent. In about two hours we began to emerge from the wood, and by 9 A.M. we were fairly upon the lava. It was an old lava-stream, with various species of *Epacris*, a red whortle-berry, and similar plants growing in its crevices. Our course this morning had diverged a little to the north and then to the south of west, but now we made right for the upper crater on the rounded back of Mauna Loa, bearing about west. Before us lay a vast wilderness. On either hand belts of wood that had escaped comparatively recent eruptions struggled yet a little higher up the mountain-side. We passed several large caverns, once the ducts of molten lava, and formed of the cooled upper crust of the lava-current,—and heaps of stones, erected to mark a place where a horse and, if I understood rightly, some natives had perished. About fifty years ago, indeed, half a native army were smothered by an eruption of ashes from Kilauea. Proceeding onwards over lava and loose porous stones, like pumice, only harder and somewhat heavier, we arrived at about 11 A.M. at a few bushes and koa-trees, a little oasis of coarse grass, an old hut, and a deep pool of delicious water in a cave. Here the old track to the north-west side of the island turns northward, passing between Mauna Loa and Mauna Kea. We halted here to refresh ourselves for a few moments, and then pursued our upward course over the bare lava. At about 3 P.M., however, the guide, disappointed in his expectations of finding water in a cavern, altered his plan, and, instead of keeping his westerly course for the upper crater, turned to the right (north-west) to find water at a spot some miles below the lower one. The consequence was that we left a comparatively smooth tract of old lava and toiled mile after mile over loose sharp stones and scoriæ, of every size and shape, and piled in the wildest confusion. Shortly before sun-set we found a little water amongst a few solitary stunted bushes, and then, turning westward, shaped our course directly for the lower crater of the two which were sending out dense volumes of smoke above us. We lay down for the night on a little patch of half-vitrified ashes: I estimated that we were now about 9000 feet above the sea. The next morning we started before sunrise. Having found a few dry sticks, I endeavoured to make some tea, but the water boiled away without attaining sufficient heat to effect my object, owing, I suppose, to the height. Our way lay mile after mile over loose, light scoria-boulders, yeasty-looking basins and tortuous folds and waves of solidified lava, caverns whence the hot lava had flowed away, hillocks generally of small stones burnt to a deep orange-red, and here and there little smooth spaces covered with ashes: altogether, dark and dreary in colour, without a living thing or a green blade to vivify its deathfulness. That morning we passed the site of the eruption of 1852. The view thence of the opposite mountain of Mauna Kea was most glorious. The old conical craters on its summit covered with newly fallen snow,—its huge outline shadowy and dim,—the clouds of smoke that rose round its base from the valley down which the present flood of lava is flowing,—the wild dreariness of the foreground,—and the tropical sky above—formed a scene almost indescribably grand and wonderful.

About midday I had arrived at the lava of the present eruption, at a spot about a mile and a half below the lower crater and about three miles below the upper one; whilst, as far as the eye could reach, I could trace its devastating course in the valley and forests below. The stream of fresh lava at this point was about two miles in breadth, of a dark dull-greenish colour, with a metallic lustre. Its surface presented every variety of form and distortion;—here wreathed about like rolls of shrivelled parchment,—there burst in cooling into slabs and fragments,—sometimes with a smooth surface, only broken by cracks and fissures,—in other places twisted like strands of coiled rope, or rolled out into huge waves and serpentine convolutions. In many places smoke or steam was still rising; and, in walking upon it, it was often hot to the feet, especially when, as frequently occurred, the upper coating broke through beneath the tread, causing a fall amongst hot lava and sulphurous steam, suggestive at first of no pleasant ideas, for below the hardened surface flowed down the liquid fire. After walking some distance across the recent lava, I obtained a good view of the fiery flood below, through a broken part of the surface. The huge arch and roof of the cavern glowed red-hot, and, as with some difficulty I obtained a point directly overhanging it, the glare was perfectly scorching. The lava, at almost a white heat, flowed slowly down at the rate of about three or four miles an hour. I dropped a fragment of rock into it, which it carried floating on. There was something very impressive in its steady smooth onward course. Passing several similar abysses and fissures, I arrived at the lower crater. The upper crust of the lava having cooled, the discharge was there entirely subterranean. Some dark fantastically shaped rocks, volumes of smoke, and some heaps of small stones, one of which containing a great proportion of sulphur was burning most furiously,—the whole surrounded by an ocean of partially cooled lava,—such was the lower crater. I walked on as well as I could until I reached one of the mounds or heaps of rocks forming a side of the crater. Lying down on the hot stones, I attempted to look over, as it were, down a gigantic chimney, to see the boiling lava which I heard seething and bubbling. I got my head over the edge, and had just time to see a long broad fissure full of smoke, when I was almost suffocated with smoke and sulphuric acid gas, and thought myself fortunate to be able to retreat in safety. After leaving this, I was joined by my "guide," whom I had not seen for some time before; indeed the smoke and darkness were so great that I had had some misgivings of his finding me again. He informed me that the other natives, who had been much tired yesterday, were thoroughly exhausted and unable to reach the summit, and that they must await our return where they were.

The upper crater is about a mile above the lower one. The intermediate space presents the same chaotic confusion of loose scoriaceous rocks, torn and burst asunder, and lava, warm and steaming, some of it lying in loose flakes, as if it had been thrown into the air and fallen with a splash. The upper crater seemed to be composed of an infinity of steam- and smoke-vents at the foot and on the sides of two large mounds or hills of small loose stones, which no doubt they had thrown up. It sent up volumes of red smoke and partially ignited gases. No doubt at night it would have appeared as actual flame to a considerable height. In one place, above a small mound or crater-mouth, this was most apparent, rising like the panting puffs of a steam-engine. * * * * *

The height of this crater is about 12,000 feet above the sea-level, being about 1500 feet below the summit of the mountain, which is, I should think, at least six or eight miles distant, the rise from the craters to the summit being extremely gradual.

Our sleeping-place was about 500 feet below the level of the craters: the night was fine with us; but, whilst above us the craters rolled up dark columns of smoke, below, over Hilo and Kilauea, raged a magnificent thunderstorm. The level of the top of the clouds was somewhat below us, and along it played flashes of the most vivid lightning, whilst the thunder-peals seemed to roll up from the valley below. Later in the night it rained, and in the morning, though in the tropics, the exterior of the fur-rug in which I slept was white with hoar-frost.

I will not trouble you with the particulars of our descent from the mountain; it would be little more than a recapitulation, though we pursued a somewhat different route. To give some idea of the nature of the walking, I may state that a pair of the stoutest English shooting-boots literally fell to pieces before I had been twenty-four hours on the lava, and were in fact cut through in many places in the first half-hour of our traverse over loose scoriæ. Fortunately I had a second pair, which, though lighter, held together about ten hours, just long enough to get me back to Kilauea. The distance from Kilauea to the craters is about thirty miles. * * * * *

Before laying down my pen, I may mention that during our stay in the Sandwich group we felt one very slight shock of earthquake when in the Island of Maui; but were informed that earthquakes of any consequence are quite unknown there. Recent volcanic eruptions have been, I believe, entirely confined to the Island of Hawaii, though all the group is volcanic. On Maui there is an enormous extinct crater, said to be twenty-four miles in circumference, and containing cones themselves of mountain-like dimensions. I will only add, that the heights of mountains given are taken on the authority of Wilkes, Douglas, or other sources.

Chideock House, July 12th, 1856.

2. *On the* VOLCANIC ERUPTIONS *in* HAWAII. By the Rev. TITUS COAN. In a Letter to W. MILLER, Esq., H.M. Consul-General for the Sandwich Islands.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(Abridged.)

[This communication is a letter addressed to and transmitted by Mr. Miller*, H.M. Consul-General at Woahoo. It describes some remarkable volcanic eruptions in the Island of Hawaii (Owhyhee), of which Mr. Coan was an eye-witness, during the last sixteen years; and includes an account of the great eruption of 1855–56. Mr. Coan has been the Resident Protestant Missionary at Hilo for twenty-one years; and was attending at the Annual Meeting in Honolulu when he wrote his letter.

In a despatch from Mr. Miller†, dated July 30, 1856, the eruption in Hawaii is stated to be still active; and a copy of 'The Pacific Commercial Advertiser' newspaper, accompanying this despatch, contains a further notice of the eruption, which will be quoted in the sequel.—EDIT.]

(1840.)—At the time of the great eruption from Kilauea, in 1840, an immense flood of molten rock forced itself under the mural sides of the great crater, at the depth of 1000 feet, pursuing its way towards the sea in subterranean galleries for ten miles,—cracking the superincumbent strata, and throwing up occasional jets of smoke, steam, gases, and lava, until the fiery flood broke ground, and rolled down in a burning deluge, from one to four miles wide, sweeping away forest and hamlet, and filling the heavens with its murky clouds and its lurid glare. In three days it reached the sea, having travelled thirty miles; and for two weeks it plunged in a vast fiery cataract, a mile wide, over a precipice some 50 feet high. The commotion, the detonations, the rolling and gyrating clouds of ascending vapour were awfully sublime. The ocean was heated for twenty miles along the coast, and thousands of marine animals were killed.

(1843.)—In 1843 a great eruption burst from the summit of Mauna Loa. The lava rushed with terrific force down the northern slope of the Mount to the base of Mauna Kea, where it divided into two broad streams; one turning N.E. towards Hilo, and the other N.W. towards Waimea. This flood was about thirty miles long, and from one to three miles wide. I visited it when in intense action, and traced the stream from its terminus to its crater on the summit of the Mount, sometimes walking over the incandescent stream on its hardened arches, and sometimes skirting along its verge.

(1852.)—In 1852 a crater suddenly opened on the top of the Mauna Loa, from which a fiery column shot up several hundred feet,

* For previous notices, by Mr. Miller, of the Eruption of Mauna Loa, see Quart. Journ. Geol. Soc. vol. xii. pp. 171 & 386.

† Also read at this Evening Meeting.

illuminating the whole summit of the Mount, and flashing with intense glare down to the shores of Hilo and far off at sea. In two days this valve closed, and in two more another opened on the side of the Mount, some fifteen miles below its summit; and from this awful furnace a fiery column, about 1000 feet in diameter, shot upwards to the height of from 500 to 1000 feet. This roaring fire-fountain was thus sustained for about twenty days,—filling the atmosphere with cinders, lava-filaments, gaseous vapours, and smoke. By night our houses and fields were lighted up so that men might labour, or travel, or read without other light; and by day the sun's rays scarcely struggled through the dense atmosphere.

This crater I visited when it was in most vehement action; and I spent one sleepless night in close proximity to its dazzling fires. The molten stream from this fountain swept through the forests to within ten or twelve miles of Hilo.

(May 1855.)—In May and June 1855, the action in the great crater of Kilauea became fearfully intense. This crater is about eight miles in circuit, and three miles in its longest diameter. Its depth varies from 700 to 1200 feet, the immense floor rising by upheaving forces, or subsiding by the subterranean escape of the molten flood below. During the period referred to, the melted lavas forced themselves to the surface of the floor, or hardened bottom of the crater, at more than a hundred points; and the ample area was thickly spangled with lakes, pools, cones, jets, streams, fountains, and lines of red-hot lava, boiling, raging, and glaring like countless furnaces in blast. So intense was the heat that visitors were unable to descend into the crater; and even spectators upon the banks, 700 feet above the fires, were compelled to retire from the verge of the precipice, unable to look directly down upon the burning abyss below. I visited the scene on the 4th of July, and, though the fiery tumult had much abated, I could count readily one hundred boiling lakes of fire.

(Aug. 1855.)—I come now to the present eruption of Hawaii, the grandest in the memory of the now existing generation. On the evening of the 11th of August 1855 a small point of light was noticed, resembling a brilliant star, on the apex of Mauna Loa ("long mount"), and in full view from Hilo, Byron's Bay. This bright point soon rose and expanded, filling the heavens with a dazzling glare. The eruption progressed with amazing force and rapidity, rolling its wide fiery floods over the mountain's summit down to its base with appalling fury.

Day after day the action increased, filling the air with smoke, which darkened our entire horizon, and desolating immense tracts, once clothed with waving forests and adorned with tropical verdure.

This eruption has now been in progress nearly ten months, and still the awful furnace is in blast. The amount of matter disgorged is enormous. The main stream is nearly seventy miles long (including its windings), from one to five miles wide, and varying from ten to several hundred feet in depth. It approached within five miles of Byron's Bay, heading directly for our town and harbour, and threatened to bury all in fiery ruin. But on the morning of the 13th of February, whilst coming with relentless energy down the rocky channel of a river, evaporating the waters, filling the basins, leaping the precipices, and kindling the thickets along its banks, it suddenly ceased to flow,—the whole terminus refrigerated, the fusion retreating towards the mountain, first one, then two, three, and four miles, where the lava gushes up vertically, forming hills, caves, ridges, towers, battlements, and innumerable tunnels, or spreads laterally, consuming the thicket along its margin. From that time to the present the lava-current has made no progress seaward.

*Visit to the Summit-crater of Mauna Loa**.—Our party consisted of an American gentleman, four natives, and myself. We left Hilo on the morning of the 2nd of Oct. 1855; and, as there was no path through the dense forest, some thirty miles wide, interposed between us and the mountain, we took the channel of a wild stream called *Wailuku* ("river of destruction") as our clue by which to thread our way up to the burning Mount. We advanced about twelve miles the first day, wading in the water, leaping from rock to rock in the stream, crossing and recrossing uncounted times, beating through the jungle along the banks to avoid a cataract, an impassable rapid, or a deep reach, and encamping at night at the roots of a large tree by the side of the stream.—Oct. 3rd. We proceeded about twelve miles more along the rocky bed of this wild romantic stream. During both of these days the forest was filled with volcanic smoke, which gave a solemn aspect to every object around. At night we made our bed of ferns under the trunk of a prostrate tree, and here we saw the gleaming of the fires as they lighted up the forest some five miles distant on our left. We had passed the end of the lava-stream as it swerved on through the thicket towards Hilo; but, as the jungle was almost impenetrable, we determined to ascend the stream until fairly out of the woods, when we would lay our course direct for the lava-flow.

At $1\frac{1}{2}$ P.M. on the third day we were fairly out of the forest and in an open rolling country of about twenty miles wide, lying between the woods and the bases of the mountains.

After emerging from the forest, we skirted along its upper borders at right angles with the channel we had left, and at night found ourselves near the borders of the lava-current. We encamped in a cave, watching during most of the night the fantastic and ever-varying play of the fires as they gleamed in the burning forest below us, and as they glowed in points and lines over the high plains and up the cleft mountain to the crater above, where the incandescent bowels of the earth were being poured out with a force which seemed to transcend all our ideas of terrestrial dynamics. The next morning (Friday) we walked up the left bank of the lava-stream until 10 o'clock.

* A detailed account of this visit has appeared in the 'New York Tribune,' the 'Pacific Commercial Advertiser,' and in Silliman's 'American Journal,' 1856, p. 139.

We judged it to be five or six miles wide at this point. Finding a narrower place, and wishing to shorten the distance by cutting off the windings of the stream, we crossed over to its right bank, the passage occupying one hour and fifteen minutes. At this point the whole surface of the lava was solidified, while the molten flood moved on below like water under ice in a river. The superficial crust of the lava was crackling with heat and emitting mineral-gases at innumerable points. Along the margin numerous trees lay crushed, half-charred, and smouldering upon the hardened lava.

All this day we passed up the lava-stream, sometimes on its surface, and sometimes along its smoking banks, which often rose in frowning battlements and ragged precipices to the height of 50 or 100 feet above us.

At night we slept on the cooled lava, above the line of vegetation. From this elevation we had an impressive view of these devouring fires, as they rushed in dazzling brilliancy down their burning duct, covered for the most part by a solidified crust, but revealed at many points along the line of flow by openings in the roof, which served as valves for the escaping gases.

Early on Saturday we were ascending our rugged pathway amidst steam, smoke, and heat. The ascent was rough and toilsome in the extreme. The atmosphere was rare, and what added much to our sufferings was the want of water. Early on the morning of Friday we had unwittingly passed the last pool of water; and, having only one pint in our flask, this was our whole supply for six men, from Friday morning until Monday, A.M.

Upward and upward we urged our weary way upon the heated roof of the lava, passing, as we ascended, opening after opening, through which we looked upon the igneous river as it rushed down its vitrified duct at the rate of forty miles an hour. The lava-current at this high point on the Mount was fearful, the heat incandescent, and the dynamic force wonderful. The fire-duct was laid from 25 to 100 feet deep down the sides of the Mount; and the occasional openings through the arches or superincumbent strata were from 1 to 40 fathoms in diameter. Into these orifices we cast large stones, which, as soon as they struck the surface of the hurrying flood, passed down the stream in an indistinct and instantaneous blaze. Through openings in the mountain we could also see subterranean cataracts of molten rock leaping precipices of 25 or 50 feet. The whole scene was awful, defying description. Struggling upwards amidst hills, cones, ridges, pits, and ravines of jagged and smoking lava, we came at 1 P.M. to the terminal or summit crater, and, mounting to the highest crest of its banks, we looked down as into the very throat of hell.

Instead of a well-defined circular crater, we found the summit of the Mount rent into yawning fissures, on each bank of which immense masses of scoriæ, lava, pumice, tuff, and cinders were piled in the form of elongated cones, rent longitudinally, while the inner walls were hung with burning stalactites, and festooned with a capillary or filamentous lava, called *Pele's hair*, and much resembling the hair of a human being. These elongated cones, overlooking the yawning fissures, were vertical, retreating, or overhanging, on their inner sides: and immense avalanches were often precipitated from their faces and toppling crests into the yawning gulf below. In this way the fissures were much choked, and the lava, which now went off by a lateral subterranean chamber, probably 1000 feet below the surface, could not be seen at this point. It first makes its appearance through the openings several miles down the slope of the Mount, as before described. But the fearful rush of white smoke and gases from these fissures on the summit fills one with awe, and the spectator must use his utmost care lest the fierce whirlwinds which gyrate and sweep over these heated regions throw him over, or strangle him with sulphurous gases.

These high realms are covered with recent deposits from the eruption, scattered widely and wildly on every hand. The whole summit of the mountain was covered with smoke, which darkened the sun and obscured every object a few rods distant.

We encamped on the Mount from Saturday until Monday, when we descended, and by forced marches reached Hilo on Thursday, having been absent ten days.

Visits to the Lava-current.—About the 1st of November I made my first visit* to the terminus of the lava-current, as it was burning its way through the forest and within about fifteen miles of Hilo. My companion on this occasion was Mr. Ritson. Penetrating a few miles into the jungle, we came into the bed of a considerable stream of water, up which we waded among slippery stones and in a drenching rain with considerable difficulty. On the evening of the second day, weary, soaked, and nearly discouraged with the prospect of a dark, dreary, and drenching night in the jungle without fire or shelter, we came suddenly upon the burning lava, some three miles wide, consuming the thicket, prostrating lofty trees, and glowing with innumerable fires. Night was upon us, and we halted under a tree within 6 feet of the lava-stream, which served to boil our tea, roast our ham, dry our clothes, and keep us warm through the long and stormy, but intensely interesting night.

The pyrotechnical scene was indescribable: standing under our tree we could survey an area of some fifteen square miles, over which countless fires were gleaming with extreme brilliancy. The jungle was burning and trees were falling; the rending of the rocks, the detonation of gases, clouds of steam from boiling water, and scintillations from burning leaves filled the atmosphere; and the red glare above resembled a firmament on fire. During the night we were nearly surrounded by the advancing lava; and, when we decamped in the morning, we left our sheltering tree in flames.

We retraced our steps, but the rains had swollen the stream up which we waded, so that our way back was more toilsome and peril-

* An account of this visit is given also in Silliman's 'American Journal,' 1856, p. 237.

ous than when we ascended. We reached home on the fourth day, gratified to oppression with the wonders we had seen.

Shortly after this visit the lava fell into the water-course above referred to, evaporating the water, and filling and obliterating the channel for about ten miles.

I have since made five visits to the lava-current; each visit marked with some new phase of peculiar interest. I have seen the igneous stream pour all night long over a precipice of 60 feet; and I have also seen it fall over another of 32 feet into a basin of water deep and large enough to float a frigate; whilst all night long, clouds of steam rolled up in fleecy wreaths towards heaven.

Honolulu, 31st May, 1856.

[The volcanic phenomena of Hawaii are noticed in the 'American Journal of Science,' new series, 1856, vol. xxi. pp.100, 139, 237, 241; also in the Bullet. Soc. Géol. France, vol. xii. p. 306.—Edit.]

[We learn from 'The Pacific Commercial Advertiser' of July 24, 1856 (enclosed in Mr. Miller's despatch above alluded to), that at that date fresh or molten lava was not met with until about three miles above the lowest point which it reached in November 1855, or at about eight miles from Hilo. The flow from the mountain still continued, however, though with diminished force; and the lava-stream appeared to be bursting laterally through its crust, and flowing off to the right and left.

The same informant describes the seat of this eruption as being in the old traditional crater of Mokuaweoweo, on the north or north-westerly side of Mauna Loa, some 12,000 feet above the sea, and 2000 feet below the summit of the mountain. Kilauea, the old open crater, is on the opposite side of the mountain, about 7500 feet lower, and about thirty miles distant. The latter crater has remained in its usual condition, without overflowing, during the late eruption from the new vent.

The progress of the lava-current from the new crater appears to have been very rapid down the side of the mountain to the valley between Mauna Loa and Mauna Kea; thence it soon reached the almost impenetrable forests, which form a belt round the mountains, commencing at about three miles from the sea, and usually extending up the mountain-sides for twenty or thirty miles. These offered a temporary check; but the lava burnt a passage into them to the distance of nearly twelve miles at the rate of about half a mile a week. During the first three months there did not appear to be any change in the force of the eruption. The lava-current, in all its windings, must be about sixty-five miles long; the lower part coming nearly within five or six miles of Hilo. It varies from three to ten miles in width, sometimes branching off, and then running together, forming islands. The lava-stream varies, according to the surface of the ground, from 20 to 300 feet in depth. The area overflowed by lava has been estimated to be at least 200,000 acres.—EDIT.]

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3. *Further Notice of the* ERUPTION *of* MAUNA LOA. By W. MILLER, Esq., H.M. Consul-General for the Sandwich Islands.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(See the preceding communication, page 170.)

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4. *On the Occurrence of an* EARTHQUAKE *at* RHODES. By R. CAMPBELL, Esq., H.M. Consul at Rhodes.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(Abstract.)

THIS communication referred to the severe shock of earthquake which was felt at the Island of Rhodes on the 12th October at about 3 o'clock A.M. It lasted for nearly two minutes, and was accompanied with great destruction of life and property. Its first motion was vertical, the second horizontal, and the third vertical. The shock was severe in the adjacent islands of Halki, Scarpantos, and Cassos; and was slightly felt in the island of Symi; it caused much damage also at Marmarizza on the coast opposite.

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5. *Additional Observations on the* GEOLOGY *of* BULGARIA. By Capt. T. A. B. SPRATT, R.N., F.R.S., F.G.S.

[Having again visited the Bulgarian coast, Captain Spratt was enabled to confirm his observations on the freshwater deposits of the Dobrudcha, which were read before the Society in June last. These additional notices have been printed in the last number of the Journal (No. 49, p. 75, &c.), in connexion with the communication to which they have reference.]

DECEMBER 17, 1856.

R. E. Arden, Esq., and W. B. Webster, Esq., were elected Fellows.

The following communications were read :—

1. *On the* FRESHWATER DEPOSITS *of* EUBŒA, *the Coast of* GREECE, *and* SALONIKA. By Capt. T. A. B. SPRATT, R.N., F.R.S., F.G.S.

IN a paper recently sent to the Society, containing geological notes, collected during the war, on the Bulgarian coast of the Black Sea, and on the coast of the Sea of Marmora and the Dardanelles, I have referred to some extensive freshwater formations in Eubœa and on the western coast of the Archipelago *, which I examined some years ago, but the results of which examination were not communicated to the Society. I have now put together my notes made when examining these several localities ; but not having the fossils before me, this communication is necessarily imperfect.

The fossils were deposited with my lamented friend E. Forbes, at the Museum of Economic Geology, soon after they were collected ; but as he had in view their publication in connexion with some contemplated work of his own on the Ægean, the localities have remained undescribed ; and, this object being now lost by the premature death of my deeply lamented companion and friend, the notes are now drawn up, especially on account of their connexion with the specimens from the eastern point of the Archipelago, and the accompanying memoir, recently communicated to the Society.

They are also connected with the notes on the freshwater deposits of the shores of the Smyrna Gulf, and the islands of Samos and Eubœa, already published in the Society's Journal †.

In the Samian and also in the Eubœan and Bœotian deposits, there were shown to be two distinct groups, unconformable. The upper was described as a group of reddish marls, sands, and gravels, overlying the white marls and compact white limestones, of undoubted freshwater origin, and supposed, from the type of the fossils, to be of the Eocene age.

With regard to the upper group, I never had any decided fossil evidence to indicate its origin until 1846 and 1847, when I extended my examinations into the northern channel of Eubœa and coasts adjacent.

Eubœan and Locrian Coasts.—My remarks on the geology of the northern shores of the Eubœan channel were published in the paper

* Quart. Journ. Geol. Soc. No. 49. p. 80.

† "Observations on the Geology of the Southern part of the Gulf of Smyrna," &c., Quart. Journ. Geol. Soc. vol. i. p. 156 ; "Remarks on the Geology of the Island of Samos," ibid. vol. iii. p. 65 ; and "On the Geology of a part of Eubœa and Bœotia," ibid. p. 67.

above referred to; and I now continue the observations from the town of Chalcis, at the central portion of the western coast of Eubœa. This town stands upon a protrusion of serpentine; and on either side extend masses of Hippurite-limestone and associated schists and shales, rising into elevated ridges 2000 and 3000 feet high.

In the broad valleys and bays formed by the curvature of these ridges and mountains are everywhere to be found one or other of the two groups of tertiary deposits which are so well developed at Oropo and in the hills north of it *.

The first of these basins to the north of Chalcis is the Steni Valley, lying at the foot of Mount Delphi, but open to the sea at Politika. This is about eight miles square, and seemed to be composed of both of the freshwater groups; the beds lying nearly horizontal. They were identified as being of freshwater origin in crossing this basin, on a journey from Chalcis to Mount Delphi; and a few fossils were procured, including a rather large-sized *Ampullaria*, near the village of Gides, at about 700 feet above the sea. But the examination was too hasty to enable me to give sections or details. The overlying red sands and gravels did not appear to be more than 50 or 60 feet thick at any place where met with; and they were often wanting.

At the foot of the mountains, rising from the margin of the valley under Steni, a serpentine protrudes beneath disturbed and altered schists and limestones, which dip to the N.E. at angles from 50° to 70°.

The next group of deposits of freshwater origin forms the entire promontory of Melasina in the Eparkeia of Atalanta on the Locrian coast. This is almost wholly composed of white compact strata of the lower lacustrine series; but it is capped by some fragments of red marls, gravels, and sands, which seem to be of subsequent date to either freshwater group, unless they form an upper fragment of the latter. The thickness of these deposits is nearly 1000 feet. Masses of the Hippurite-limestone, however, rise through them, and were no doubt islets or rocks in the ancient lake. This Melasina group dips to the S.E. at an angle of about 10°.

The Atalanta valley or basin is composed of low ridges of reddish marls, sands, and gravel; these, being soft and subject to rapid waste, are channeled into deep ravines, in which the deposits are well exposed, and exhibit a great abundance of fossils. By means of the fossils this softer group is clearly identified as of freshwater origin; and apparently it was contemporary with the newer freshwater deposits before described as occurring in the southern division of the Archipelago, viz. Xanthus †, Rhodes ‡, Kos, and Cerigo; and I may say, from my more recent discoveries, in Crete also, where similar freshwater deposits exist at several localities.

The *Atalanta deposits* are most fossiliferous near the village of

* See Map, pl. 4, Quart. Journ. Geol. Soc. vol. iii.

† Travels in Lycia, vol. ii. p. 164, &c.; Quart. Journ. Geol. Soc. vol. ii. p. 10.

‡ Proceed. Geol. Soc. vol. iii. p. 774.

Livonati, and near Skander Aga. They consist of reddish, yellow, grey, and white sandy marls, and brown sands and gravels; having altogether a thickness of more than 200 feet. (See fig. p. 180.)

The following is the ascending order of the deposits in the Livonati hills:—

A. 30 feet of reddish-yellow loose sands, with an occasional layer of sandstone, in which are *Paludina*, *Neritina*, and *Melania*.

B. 12 feet of grey and yellow sands and sandstones, with the same fossils more numerous, but with the Xanthian and Italian fossil, the *Limnæa Adelina* *; which I found here in great abundance, and in an excellent state of preservation.

C. 3 feet of gravels and white marls, and 2 feet of indurated and laminated marls. No fossils.

D. 6 inches of a grey sandy marl and ferruginous sandy loam; in which several *Planorbes* and *Paludinæ* are compressed: this passes into 4 ft. 6 in. of greenish sandy marls.

E. 1 foot of a purple peaty marl, containing two or three species of *Planorbis*. The peat is overlaid by 4 feet of alternating sands and gravels, in the lowest of which the fossils are very numerous, particularly *Limnæa Adelina*, a large *Cyclas*, a large *Paludina*, and a *Dreissena*. These shells appear to have been suddenly swept together during some disturbance, by which the shells then living on the weedy bottom of the lake (as shown by the peat below) were swept along and deposited in the turbid waters that scattered the gravels. The latter are composed of fragments of the secondary limestones and schists, and vary from the size of a pea to that of a walnut.

F. 12 feet of stratified sands and sandstones of a grey colour. These pass into an oolitic sandstone, full of impressions of a striated *Melania*. The sandstone is overlaid by 10 feet of gravels, white marls, and sandstone, without fossils.

G. 30 feet of sands, sandstones, and marls succeed, in the upper series of which *Limnæa*, *Helix*, and *Paludina*, and a carinated *Planorbis* are very abundant.

H. 100 feet of unfossiliferous sands, marls, and gravels succeed; which are in some of the highest positions capped by 50 to 60 feet of reddish loamy earth and gravels. The latter seem to have been deposited during a troubled and highly turbid condition of the waters of the lake; most probably at its final rupture, and on the admission of the sea into the lower parts of this old lake; for there is evidence of a higher sea-level than the present near the coast to the N.E. of Livonati, where, at about 40 feet above the present shore-line, on the flanks of a low ridge, I found a thin bed of sand containing *Cardium* and drifted fragments of freshwater shells.

* Travels in Lycia, vol. i. p. 24, and vol. ii. p. 177.

Section of the Freshwater Deposits at the Livonati Hills on the Locrian Coast (see p. 179).

13. Loam and gravel.

12. Sands, marls, and gravels.

11. Sands, sandstones, and marls. *Planorbis*, *Limnæa*, *Helix*, and *Paludina.*

10. Gravel, marls, and sandstone.

9. Oolitic sandstone (with *Melania*), sands, and sandstone.

8. Sands and gravels. *Paludina*, *Limnæa* (*L. Adelina*), *Cyclas*, and *Dreissena.*

7. Purple peaty mud. *Planorbis.*

6. Sandy marls.

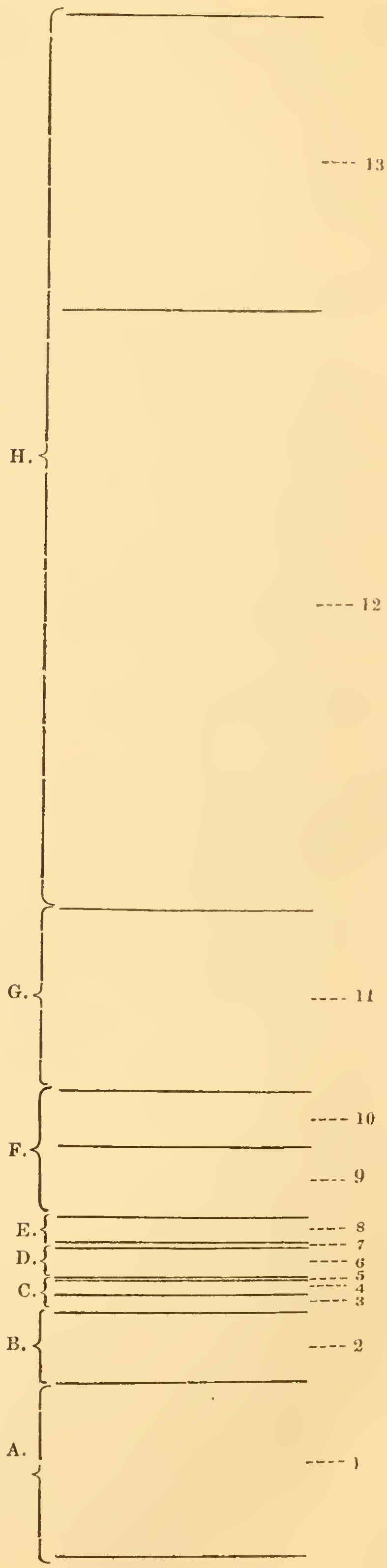
5. Sandy marl and loam. *Planorbis* and *Paludina.*

4. Marls.

3. Gravels and marls.

2. Sands and sandstone. *Neritina*, *Melania*, *Paludina*, and *Limnæa* (*L. Adelina*).

1. Sands and sandstone. *Neritina*, *Melania*, and *Paludina.*



[In a letter to the Assistant-Secretary, dated March 11, 1857, the author expresses his belief that the ossiferous gravels of Pikerni, on the flank of Pentelicus, not far from Athens, are of the same age as the Eubœan and Locrian gravels that overlie the freshwater marls and limestones; although at Pikerni the latter appear to be absent. These ossiferous gravels of Attica and their interesting fossils have been described by Wagner and Roth in the Munich Transactions, and by Duvernoy and Gaudry in the 'Comptes Rendus.' They are regarded as being of Miocene age.—EDIT.]

To the west and south-west the Atalanta freshwater deposits are bounded by the Hippurite-limestone and the associated underlying shales and schists.

At the foot of the Acropolis of Opus there is a protrusion of serpentine, by which the colour of the schists has changed into a blackish-brown, and that of the shales into a deep purple. The schists and shales dip to the S.W., at an angle of 60°. The hill immediately over Atalanta is a mass of red trachyte, of more recent date; and which was probably an outpouring of igneous matter at the breaking up of the lake.

On the opposite side of the channel of Egripo, the Hippurite-limestones and the schist are also highly disturbed by volcanic rocks, dipping generally to the N.E. at from 30° to 60°; but they are almost vertical near several trap and serpentine protrusions.

Mount Kandili (in Eubœa), opposite the Melasina promontory, is an uplifted mass of limestone, with serpentine and disturbed schists flanking it to the north.

At Mount Balanti over Lipso Bay, the limestone also dips to the N.E. at 55°; but over Lipso a porphyritic trap throws off the schists and shales in contact with it, at high angles; and a vent to the subterranean heat still exists at the point of the Bay immediately under Mount Balanti, in a hot-spring of the high temperature of 170°.

Between Mounts Kandili and Balanti on the Eubœan coast is a district bordering the shore, in which the limestone-deposits are again largely developed: from Limnæ northwards they are chiefly the white compact calcareous strata of the lower group. But they are overlaid (and unconformably, as I thought, from a difference of the dip) by some remnants of a soft and wasting group of marls and sands corresponding to the Livonati series, which towards the N.E. part of the district (the direction of their dip in general) are better developed; each formation preserving its characteristic fossils, as will be seen by the specimens at the Museum of Practical Geology.

The *Planorbis* of the lower group is apparently *Planorbis rotundatus* * of the Smyrna and Samos deposits.

In the vicinity of Limnæ are thick gravel-beds, lying on the flanks of the freshwater strata, and also capping the upper, as at Livonati. Containing fragments of the older freshwater rocks, as well as of the

* Quart. Journ. Geol. Soc. vol. i. p. 163.

secondary rocks, the gravels are evidently subsequent in date to both, and seem to have attained a considerable thickness on the higher part of the ridges towards Kerokovi.

Lignite, similar to that of Oropo *, occurs in a valley to the N.E. of Limnæ, but has not been worked.

Interior of Eubœa.—The next localities to be noticed are those within the interior of Eubœa, viz. the Mandondi valley, lying on the east of Mount Kandili, and opening into the Ægean Sea; next the Xero Khori valley, opening into the north channel of Eubœa. In the former both formations are evident; the older or lower being that in the neighbourhood of Agia Anna, and the more recent being the softer series of marls, sands, and gravels lying in the lower part of the basin towards Akmet Aga. Hills of serpentine almost enclose them on the east.

The Xero Khori hills seem to be exclusively of red marls, sands, and gravels, closely resembling the Atalanta deposits. And, although I examined several good sections in the ravines and water-courses, I found only a few fragments of some fragile shell which appeared to be a *Helix*. These deposits have a slight dip to the north.

Gulf of Stylida.—The lesser ridges bordering the Gulf of Stylida (Gulf of Zeitoum) were found to be composed of the same deposits, particularly in the district of Molo, to the east of Thermopyle, where they extend for several miles. I examined them as far as Boudounitza, finding many freshwater fossils scattered through the deposits, similar to those procured at Livonati. These beds attain a thickness of 400 and 500 feet, and dip to the S.W. at an angle of 18° from the shores of the Gulf and towards the higher mountains enclosing them.

On the opposite side of the Gulf (of Zeitoum) these deposits seem to have been for the most part swept away, except at Ekinos, the acropolis of which stands upon a tilted fragment of white calcareous strata, that resembles the deposits of the lower lacustrine formation, and of which it may be a fragment formerly thrown up by some local movement.

Gulf of Salonika.—The Gulf of Salonika now requires a few observations, as its two shores present low hills which, extending from the base of the lofty Olympus on one side and from the Cassandrian mountains on the other, are also of freshwater origin and correspond with the latest lacustrine series, wherever I had the means of examining. They consist of the soft grey marls, sands, and gravels so characteristic of the deposits of the later period of the great ancient Levantine lake.

Near Leftero Khori, about twelve miles to the south of the Vardar river, I found the deposits to contain impressions or casts of *Limnœa* and *Paludina* in great abundance.

* Quart. Journ. Geol. Soc. vol. iii. p. 70.

Also over the "Scale" or Custom-house of Leftero Khori I found similar deposits capping a ridge about 100 feet above the sea: in these there was a *Cardium* intermixed. Further down the coast, in a cliff on the shore, I found several specimens of *Helix* similar to the one procured at Livonati.

Here also I found, on the flank of a ridge of undoubted freshwater beds, about 30 feet of a very recent or post-tertiary deposit of marine origin, with several existing shells in it, viz. *Cerithium, Cardium, Spondylus,* &c.

The promontory of Karabournou which juts out from the eastern coast, opposite to the mouth of the Vardar, shows in its cliff about 100 feet of reddish-grey marls and sands, similar to the Leftero Khori deposits. They lie horizontally, are capped by a bed of gravels and white sands, filling the hollows in the surface of the lower group, from 10 to 12 feet in thickness, and are of a late and probably marine origin.

The cliffs surrounding the promontory present good sections of the deposits; but, although I examined them through a distance of three or four miles, not a fossil shell was found to indicate positively that the lower were of freshwater origin. But I was fortunate in finding some fossil bones of a large animal, though much scattered and broken. These were sent to Professor Forbes at the Museum in Jermyn Street, with numerous vertebræ of a snake, found in the marls at about one mile N.E. of the Cape. The vertebræ were given to Professor Owen soon after they reached the Museum, and were, I believe, considered to be rare and interesting*.

In concluding this account of the freshwater deposits on the western side of the Archipelago, I shall draw attention to the fact that no marine deposits but such as are evidently of a very recent date (post-Tertiary apparently) have been mentioned. No marine formation of the earlier Tertiary ages, in fact, anywhere existing, to my knowledge, in the northern division of the Archipelago, viz. that which includes a line from the south end of Eubœa to the coast of Asia Minor at the Meander.

I know of no marine strata of the Miocene age in this division; nor indeed any Eocene deposits, unless they are represented by the older limestones and the usually associated shales and schists; but I have not been able to identify any of these as being Nummulitic; this group of rocks having *Hippurites* as the general characteristic fossil in this division of the Archipelago, as far as I have examined.

Thus it evidently appears, that, if not from the commencement, at least from the early part of the Tertiary epoch down to a very late period, a freshwater lake occupied the basin. The lake no doubt had its margin extended up the valley of the Vardar, as appears from the freshwater deposits known to exist many miles up

* Prof. Owen found that the portion of mammalian bone, from Salonika, which was submitted to him, was not determinable. The Ophidian vertebræ above referred to were described by Prof. Owen in a paper read before the Society on Jan. 7, 1857 (see further on, p. 196).—Edit.

this valley; and probably also it was continued by the Maritza valley (in Thrace) up to the foot of the Balkan. It probably covered also the basin now formed by the Sea of Marmora; for an unbroken series of these freshwater deposits extends from the entrance of the Dardanelles to St. Stephano, as will be seen by the fossils which have been recently sent to the Society from several localities on this line.

The whole of this region was, in my opinion, covered by a freshwater lake of Miocene and Pliocene age.

I shall at another opportunity touch upon the freshwater deposits on the Asiatic side of the Archipelago, in Mitylene and Tenedos, and at the Dardanelles and the Sea of Marmora: these comprise additional fragments of the great ancient Oriental lake, which I have lately had the opportunity of examining.

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2. *On the* ANALYSIS *of* WATERS *from the* TURKO-PERSIAN FRONTIER*. By Dr. THOMAS RICHARDSON and E. J. J. BROWELL, Esq. In a letter from Dr. Richardson to W. K. Loftus, Esq., F.G.S.

[The following is a report on six samples of water from the Lake of Van†, the small Lake of Ardchek, situated to the east of the former, and their vicinity, not far south-west of Ararat. They were brought home by Mr. W. Kennett Loftus.—EDIT.]

THE water marked No. 11 has a very remarkable composition, containing only traces of the ordinary saline matter and a large proportion of the two alkaline earths, lime and magnesia. It is difficult to surmise whence it has obtained these constituents, unless by assuming that it was originally a water coming off dolomite and subsequently passing through a bed of gypsum, under which circumstances a change of its constituents would take place, by a recombination among the acids and bases.

No. 10 is not unlike some of the waters which we have met with in collieries in the Newcastle district, where a large quantity of common salt is accompanied with oxide of iron. The sources of lime are very numerous.

Nos. 6 to 9 belong to a very limited class of waters found in Hungary, Egypt, &c., all more or less rich in carbonate of soda. The lake near Debretzin in Hungary contains so much of this salt, that, during the evaporation in summer, it is regularly collected and sold as an article of trade. The waters of the natron-lakes in the desert on the west bank of the Nile have a similar character, where the salt

* For the analyses of other samples of water from lakes and springs on the Turko-Persian Frontier, see Mr. Witt's paper in the Philos. Magaz. 4th ser. vol. xi. p. 257.

† See Quart. Journ. Geol. Soc. vol. xi. p. 317, &c.

has been depositing for hundreds of years. Abich has also furnished some particulars of similar waters of some lakes near Ararat. The mineral springs which supply the Laacher-See and the mineral water of Roisdorf, near Bonn, have all a similar composition, although, of course, not so rich in saline matter as the waters of these lakes, which approach, in fact, the character of *mother-liquors*: having no outlet, with a constant evaporation under a powerful sun, the saline matter accumulates, until the water can no longer hold it in solution, and then the usual deposits on the bottom and sides are formed to a depth of several inches.

The only analysis of the water of Lake Van with which we are acquainted is that of De Chancourtois, who found a potash-salt; and this is not unlikely to be present, as potash and soda so often accompany each other. The detection of potash is difficult when present in small quantities, and in our experiments on a limited supply no trace could be found.

We add a Table giving the composition of some of the above-mentioned waters in 10,000 parts.

Constituents.	1.	2.	3.	4.	5.	6.
Carbonate of soda	86·1	9·8	37·0	1·1259	9·0150	9·453
Sulphate of soda	33·3	6·9	55·7	·0959	3·1767	4·481
Chloride of sodium	93·8	49·9	213·6	·1791	5·0241	17·896
Sulphate of potash	5·5	......	......	......	......	......
Carbonate of lime	......	......	......	·5398	2·6885	3·169
Carbonate of magnesia ...	5·5	......	......	·2112	2·9269	2·804
Oxide of iron	traces	......	......	(carb.)	·1917	·105
Silica	1·8	......	......	·0295	·4968	·207
Total	226·9	66·6	306·3	2·1814	23·5197	38·115

1. Water from the Lake of Van, analysed by De Chancourtois.
2. Water from a lake near Taschburun, analysed by Abich.
3. Water from a lake to the S.E. of the smaller Ararat, analysed by Abich.
4. Water from the Laacher-See, analysed by Bischof.
5. Mineral water from Hepping, analysed by Bischof.
6. Mineral water from Roisdorf, analysed by Bischof.

The inference is therefore very direct, that the source of the constituents of your waters, Nos. 6 to 9, must be similar to those which, like the above, take their origin in volcanic districts. The decomposition of the different felspars, especially such as labradorite, which contain more soda than potash, by the action of water containing carbonic acid in solution, at once explains the composition of the waters from the Lakes Van and Ardchek.

The difference in the composition of the water from the same lake probably arises from the action of the osmotic force, which was the subject of the Bakerian lecture by Graham in 1854.

Chemical Examination of the Waters.

"No. 6. Water from the Lake of Ardchek, east of Ván (at Ardchek village)."

The reaction was slightly alkaline, and the water contained a minute quantity of solid matter in suspension. The solid residue left on evaporation evolved carbonic acid and traces of sulphuretted hydrogen, on the addition of muriatic acid.

The specific gravity was 1·0212.

"No. 7. Water from the Lake of Ardchek (from west extremity of Lake)."

The specific gravity was 1·0214.

"No. 8. Water from Lake of Ván at Mérek."

Reaction strongly alkaline, and the water contained traces of suspended matter. It had no smell, and the specific gravity was 1·0187.

"No. 9. Water from Lake of Ván at Tad Ván."

Specific gravity 1·0154.

"No. 10. Chalybeate and saline water from a hot-spring, two miles above Mershút village, up the Ardish Chaï, north of Lake Ván. Supposed temperature 165° Fahr."

Specific gravity 1·0028. The reaction was neutral, or very slightly alkaline. The water evolved a smell of putrefying organic matter, which was so persistent that it remained after evaporation to dryness and remoistening with water.

"No. 11. Acidulated Saline Spring, two miles south of Bitlis. Cold."

Specific gravity 1·0019. Had a strong odour of sulphuretted hydrogen, impregnated with decaying organic matter. Contained a considerable quantity of gas, and reacted feebly acid.

The whole of the waters were clear, except where we have mentioned having found traces of matter in suspension. The organic matter appeared to contain no nitrogen, and no nitrates were present. The proportion of gas was small, except in No. 11.

The small quantity of water at our disposal led us to boil each sample and separate the precipitate by filtration. This precipitate and the filtrate were then analysed in the usual manner. This mode of analysis will explain why we have arranged the results of our analyses in the form which follows.

This limited supply of water prevented us going more into detail in the analyses, and determining with absolute certainty the absence of iodine, &c.

Table of Analyses.

Constituents per imperial gallon.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.
Carbonate of lime	traces	traces	......	5·79	19·30	67·56
Carbonate of magnesia ...	12·77	5·16	10·68	17·26	traces	traces
Peroxide of iron .... } Alumina	·55	·24	·36	traces	·60	traces
Alumina				......	......	......
Silica	......	......	......	·92	1·40	3·00
Organic matter	traces	traces	sml. qnty.	......	traces	some qty.
Sulphate of soda	320·13	266·91	270·25	224·84	216·60	......
Carbonate of soda	616·77	751·50	451·95	404·60		......
Chloride of sodium	627·63	575·78	643·81	500·57	pr. cons. Cl Na	traces
Sulphate of lime	......	......	traces	......	sml. qnty.	......
Sulphate of magnesia ...	......	......	......	......	......	20·76
Totals	1577·85	1599·59	1377·05	1153·98	237·90	91·32

Appendix.

The authors have much pleasure in appending the following note, which has been kindly supplied by Dr. Percy, F.R.S., F.G.S.

Special attention is called by the authors of the paper to analysis No. 11, in which carbonate of lime (dissolved by excess of carbonic acid) co-exists with sulphate of magnesia, both salts being present in considerable quantity. This is explained by supposing that the water first percolates through the dolomite and then through gypsum; the carbonate of magnesia derived from the former being decomposed by the gypsum, with the formation of carbonate of lime and sulphate of magnesia. Between twenty and thirty years ago a patent was taken out by a Mr. Grisenthwaite for the manufacture of sulphate of magnesia on a similar principle. Few persons have ever heard of the process, but I saw it in operation in Nottingham, and saw tons of Epsom salts produced by it. Gypsum and calcined dolomite were put into large tanks filled with water, and carbonic acid, generated from the combustion of coke, was blown through, when sulphate of magnesia was produced. I thought it might be interesting to mention this fact, which may have a geological bearing.

The carbonate of lead not unfrequently occurring on decomposing galena may arise in a similar way. Sulphate of lead must necessarily be first formed; and, when that salt is brought in contact with water containing carbonate of lime dissolved by carbonic acid, decomposition takes place, carbonate of lead and sulphate of lime being generated. I know this by direct experiments made in my laboratory.—[J. P.]

3. *Additional Notice of the occurrence of* VOLCANIC BOMBS *in* AUSTRALASIA. By the Rev. W. B. CLARKE, A.M., F.G.S.

[Abstract.]

THE author sent in 1855 a notice of the occurrence of Volcanic Bombs in the gold-bearing alluvium of New South Wales *; and in this communication adds Victoria and Tasmania as countries in which these obsidian-bombs have been found in the alluvial drift.

One specimen was found by Mr. Milligan, Secretary of the Royal Society of Van Diemen's Land, on the Supply Rivulet, Spring Bay, River Tamar, in Tasmania, about twenty miles from Bass's Strait; the other specimen (like a bung in shape, an inch high and $1\frac{2}{10}$ inch thick at the upper part) was found near the River Wannon in the district of Portland Bay.

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4. *Notice of the occurrence of* METALLIFEROUS ORES *and of* COAL *in* SIAM. By H. J. MOYLE, Esq., and C. B. HILLIER, Esq., H.M. Consul at Bangkok.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(Abstract.)

MR. MOYLE states that in the hilly districts extending north and south, in lat. 15° 25′, near the River Chaw-Phya (Meinam) in Siam, he has discovered several apparently valuable veins of copper-ore, principally in grauwacke, and that he has applied for and obtained from the Siamese government authority to work them. He also refers to his discovery of ores of lead and silver, with enormous beds of magnetic and specular iron-ores in the same district; and describes the country to the north as consisting of carboniferous limestone, with indications of coal.

Mr. Moyle states that the numerous rivers and canals afford great facilities for the transport of the minerals from the hills; and he believes that Siam will rival any country in the East in the richness of its mineral productions.

Mr. Hillier mentions a report that beds of coal have been discovered near the sea in the district of Chantabun on the eastern coast of the Gulf of Siam.

Note.—A small box of ores, chiefly cupriferous, with a specimen of corundum, accompanied this communication from the Foreign Office; but these were not sufficient to decide the question of the value of the ores.—EDIT.

* Quart. Journ. Geol. Soc. vol. xi. p. 405.

5. *Notice of an* Ice-carried Boulder *at* Borgholm. By John Wolley, Esq.

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

At Borgholm, several weeks ago, there was shown to me a large boulder, with several smaller ones by its side, which had been brought to the place where they lay by the ice this year (1856). It was just to the north of the town, which is on the western coast of the island of Öland. This stone, like most of the large boulders in that country, was of red granite, of an oblong form, with all irregularities rounded off. Between perpendiculars it was in length about 10 feet, and in breadth about 7 feet, and it was 6 feet deep. It lay 2 or 3 feet above the present water-line, and was supported by several smaller stones, so that its under side could be seen. This under side presented indications of recent grinding, but no continuous scratches or furrows. The upper part of the stone had yellow lichens growing sparingly upon it, proving that it had been for some time above water; whilst below the yellow lichens at some distance was a belt of black colour, probably of a vegetable nature, like what is to be seen on other stones in the islets of which I am about to speak.

From the spot where the stone lay, which was some paces from the water's edge, the shore sloped gradually to some distance below the water-line, and the rock was covered with shingle. In this shingle deep furrows were ploughed, leading in one direction to the several boulders, and in the other pointing out the quarter from whence they had come. The line thus indicated seemed to touch the north-east end of an islet lying at about half an English mile distance to the N.N.W. From this island my informants believed that the stone had been carried. They were sure that there had been no such stone previously visible in that direction nearer than the islet.

Rowing out, I found that there was deep water for a considerable part of the way; and, landing at the place from which the boulders were supposed to have come, I saw that the other stones there resembled them in the vegetable growth upon them and in other respects. The ground sloped gradually round the islet, which was for the most part a heap of boulders, many of which also lay scattered round it, rising above the surface of the water.

The account given was, that in the month of February the ice was drifted by a storm from a direction between north and west,—that it was heaped up on the shore,—and that shortly afterwards a mass of stones was seen supported at a considerable height upon it. As the ice melted the stones sunk down, and were deposited in the spot where I saw them. Such occurrences are said to be not uncommon, and an intelligent, but unread man explained them in the following manner:—Stones, standing with a considerable part under water, are in the winter frozen fast. When a storm from the north comes, the level of the water is raised round Öland, and the ice lifts from the ground the stones which are attached to it. At the same time it may be partly broken up, and masses of it drifted to a considerable distance and subsequently stranded with the stones attached to them, or even driven up the shore by the field of ice pressing upon them, and heaped upon ice which had reached there previously.

I do not think that this explanation differs from that given by Sir Charles Lyell for similar phenomena. In the Lapland river Muonio I have myself seen stones of several hundredweight perched at the top of ice-heaps between 20 and 30 feet above the level of the water, where the spring-flood has been opposed by islands lying in its way.

The largest travelled block I saw upon Öland was also near Borgholm ; it was 28 feet long by 22 broad, and stood about 8 feet above the soil. It was flat and somewhat quadrangular at the top.

Stockholm, 30th June, 1856.

January 7, 1857.

J. D. Rigby, Esq., W. Peace, Esq., and W. H. Baily, Esq., were elected Fellows.

The following communications were read :—

1. *On the* Dichodon cuspidatus, *Owen*. By Professor Owen, F.R.S., F.G.S. &c.

[Plate III.]

In June 1847 I communicated to the Geological Society of London a description of certain teeth and portions of jaws of an extinct Artiodactyle Mammal, from the Upper Eocene sand of Hordwell, Hants, from which were deduced the dental characters of the genus *Dichodon* and of the species *cuspidatus**.

The parts described were of an immature individual, retaining, probably, the deciduous molars ; and having, certainly, acquired, in the upper jaw, only the first and second true molars, and in the lower jaw only the first true molar. The second true molar in that jaw was just beginning to appear above the alveolar border ; the crown of the third true molar was calcified in the upper jaw, but not in the lower one,—not sufficiently, at least, to give the true form of its crown.

I have since been favoured, by the experienced and indefatigable palæontologist, Dr. Wright, of Cheltenham, with the opportunity of examining and describing an instructive portion of the right ramus of the lower jaw of the *Dichodon cuspidatus* containing the three permanent molar teeth, *in situ*, and thus supplying the tooth, *m* 3, which was wanting to complete that part of the mature dentition of the genus.

This specimen was found by Dr. Wright near Alum Point, Isle of Wight, in a bed of greenish tough tenacious clay, No. 35 of his

* Quart. Journ. Geol. Soc. vol. iv., 1847, p. 36, pl. 4. f. 2–6.

Section*, which he regards as the equivalent of the Hordwell beds from which Mr. Pytts Falconer obtained the original fossils described by me.

The present additional fossil, figs. 1, 2, & 3, Pl. III., is noticed by Dr. Wright in his excellent "Contributions to the Palæontology of the Isle of Wight†;" but, with his accustomed liberality, the discoverer of this rare specimen remitted the full description and illustration of it to me.

The first and second molars correspond precisely, in both size and shape, with those of the lower jaw from Hordwell described and figured in Geol. Quart. Journ. vol. iv. p. 36. pl. 4. fig. 2, *m* 1, *m* 2.

The crown of each consists of four three-sided cones, in two transverse pairs, the inner cones being rather higher, more compressed, and sharper than the outer ones, and almost lanceolate in form. The inner side of the outer cones is smooth and nearly flat; that of the inner cones, fig. 2, is sinuous, convex in the middle, concave before and behind, with each angle of the base produced into a small ear-like cusp: the ridge from the hind angle of the base of the hinder and outer lobe terminates by expanding into a small cusp behind the base of the hinder and inner lobe, so that there are five basal cusps, besides the two lanceolate lobes, on the inner side of the crown of both the first and the second true molars. The other two sides of the cones meet at an open angle in the two inner cones, and at an acute angle in the two outer ones: the angles are rounded off where they meet, so that the outer part of each lobe, fig. 1, is convex, smooth, and polished.

Were the summits of the four cones to be ground down to a flat surface, there would result, from the form above described, two pairs of crescentic tracts of enamel, with their convexity turned outwards, as in the Ruminants. And this abrasion has indeed in some degree affected the first molar, *m* 1, Pl. III. fig. 3; the resulting crescentic islands, however, instead of being on a flat surface, are bowed, rising in the middle to the apex of each cone, which is hardly more worn than the part which slopes away from it on each side, along the line where the flat, or sinuous, inner side meets the other two sides of the three-sided cone. The crown of the second molar, *m* 2, is less abraded: that of the third molar, *m* 3, has lost only a strip of enamel from the ridges of the anterior pair of cones.

This tooth, agreeably with the artiodactyle type of *m* 3, has an additional pair of lobes, fig. 3, *m* 3, *g*. They are smaller than the normal ones: the inner surface of the inner lobe has an accessory cusp at the back part of its base, but not at the fore part. The fore-and-aft diameter of this tooth is 9 lines; that of the three molar teeth being 1 inch 9 lines.

The specimens described in the 'Quarterly Journal of the Geological Society,' vol. iv. 1847, demonstrated the typical character of the dental

* "Geology of the North-west coast of the Isle of Wight," Annals and Mag. Nat. Hist., ser. 2. vol. vii. p. 433.

† *Ib.* (August 1852).

formula of the *Dichodon*: viz. $i\frac{3-3}{3-3}$, $c\frac{1-1}{1-1}$, p or $d\frac{4-4}{4-4}$, $m\frac{3-3}{3-3}=44$; and that the three incisors, the canine, the four premolars, and three molars formed, as in the *Anoplotherium*, one continuous unbroken series on each side of both jaws.

The only important matter which those specimens, owing to their having belonged to an immature individual, left undecided was as to the nature of the teeth occupying the position of the premolars. The absence of any calcified germ beneath those teeth, in the lower jaw, coupled with the advanced development of the second true molar in the lower, and of the third true molar in the upper, jaws, inclined me at first to regard them as permanent teeth. A subsequent reconsideration of their characters led me to interpret the phænomena as related to a modification of the order of appearance and succession of the permanent teeth in the extinct genus*. I accordingly looked for additional specimens to obtain a knowledge of the characters of the premolar teeth, and of the permanent incisors and canines.

A portion of the upper jaw of the *Dichodon cuspidatus*, from the Hordwell sand, in the collection lately purchased of Lady Hastings by the British Museum, exhibits the three incisors, a canine, and the three anterior premolars of an adult individual, and, to judge by the degree in which the crowns of the teeth have been worn, of an aged one.

The first incisor, fig. 4, *i* 1, has a crown 4½ lines in breadth: its summit is worn flat, as far down as nearly to the level of the posterior ridge circumscribing the cavity which still remains at the outer and back part of the crown. The pointed, narrower, outer extremity of the crown overlaps the anterior facet of the outer side of the second incisor, *i* 2: the crown of this tooth is less worn; it is 4 lines in breadth; the posterior basal groove extends the whole breadth of the crown. The third incisor, *i* 3, has been partly displaced: the whole simple subcompressed root, and a part of the crown, are exposed. The canine has been entirely displaced, but the crown is fortunately preserved, adherent to the matrix outside the incisors: on the right side of the upper jaw the bottom of the simple socket for the root of the canine is shown. The crown has a breadth of 5 lines: its exterior is rather sinuous with a double convexity, as in the deciduous canine with a crown of 4 lines in breadth, in the first-described specimen. On the opposite side of the tooth the crown shows a polished surface of abrasion, as if that side had been obliquely and cleanly cut off, leaving a trace of the depression and basal ridge at the back part of the inner surface.

The form of the worn surface shows that this extended but short canine must have been worked upon by the lower canine, like a carnassial tooth or scissor-blade; but the flattened grinding surface of the succeeding premolars indicates that the cutting power of the canines was exercised upon vegetable substances.

The first premolar (Pl. III. fig. 4, *p* 1) has a breadth, or fore-and-

* "Forms and Structure of the Teeth" in "Circle of the Sciences," 8vo, 1854, p. 296.

aft extent, of crown of 7 lines, but is not thicker than 2 lines ; it has been worn down almost to the roots, which are two in number; the groove between the ridge along the inner side of the base and the rest of the crown remains : the smooth abraded horizontal surface, a line or more in breadth, slopes away from the produced mid-part of the crown, the general shape of which evidently corresponded with that of the first deciduous molar of the lower jaw (*op. cit.* pl. 4. fig. 2, *p* 1).

The second premolar, fig. 4, *p* 2, with a fore-and-aft extent of 8 lines, is 3 lines thick : the smooth abraded surface slopes away from the most prominent middle lobe of the crown, but rises so as to indicate the summit of a fore and a hind accessory lobe : the groove bounded by the inner basal ridge remains. This tooth has two fangs, the hinder one being the strongest, where the crown is thickest.

The third premolar, figs. 4 & 4 *a*, *p* 3, has been displaced, but lies attached to the matrix not far from its socket. Its crown is less worn than that of the preceding tooth, and the trilobed character is consequently better shown : its fore-and-aft extent is 8 lines, the same almost as that of the deciduous tooth (*loc. cit.* fig. 2, *p* 3) which preceded it; but the three principal lobes are thicker; and the accessory inner lobe, marked *i* in fig. 3, *p* 3, *loc. cit.*, of the deciduous tooth is more developed, the greatest thickness of the crown being 4 lines in the present premolar: the accessory tubercle at the back part of the outer side of the crown is better developed. The inner basal ridge continued from each end of the base of the inner tubercle, *i*, is well marked. The line of abrasion which follows the undulations of the tricuspid outer and inner part of the crown diminishes in breadth from the fore to the back part of the crown. The height of the middle lobe of the crown is not more than 3 lines. The thick hinder root is longitudinally grooved, as if preparatory for the bifurcation which the same root would probably present in the next tooth. Unfortunately no other tooth is preserved in this specimen, and the form and proportions of the fourth premolar of the upper jaw have still to be determined.

Sufficient, however, of the characters of the premolar series of the adult *Dichodon* are now known to confirm the deductions from the first-described evidences as to its generic distinction from *Dichobune*, Cuv. : the unusual antero-posterior extent of the low crowns of the first three premolars establishes that distinction, if even the fourth premolar should prove, as is most probable, to have a form and proportions more resembling those of the first true molar tooth. The precise form and proportions of the last true molar of the lower jaw, exhibited in Dr. Wright's specimen, afford likewise a valuable accession to the characters of this interesting Anoplotherioid extinct British quadruped.

The collection of the Marchioness of Hastings, now in the British Museum, also includes a portion of the right ramus of the lower jaw, with the last molar tooth. This tooth, fig. 5, corresponds in size and shape with that in Dr. Wright's specimen, but it is more worn, having belonged to a more aged animal. The two enamel-bounded crescents of the anterior division of the crown have been ground down into a continuous tract of dentine; they remain distinct in the middle and third divisions of the crown, fig. 5 *a*. The fore-and-aft extent of the crown is 9 lines: the depth of the jaw beneath the middle of the tooth is 11 lines.

Thus, of the genus *Dichodon*, the deciduous dentition, and the permanent dentition, save as respects the last premolar, are now known.

The formula of the deciduous dentition is—

$$i\,\frac{3-3}{3-3},\ c\,\frac{1-1}{1-1},\ dm\,\frac{4-4}{4-4}=32;$$

that of the permanent dentition is—

$$i\,\frac{3-3}{3-3},\ c\,\frac{1-1}{1-1},\ p\,\frac{4-4}{4-4},\ m\,\frac{3-3}{3-3}=44.$$

The deciduous formula is the same as that of the Hog: the permanent one differs from that of the Hog only in the displacement of *d* 1 by the development beneath it of *p* 1, and in the functional character and size of that tooth: this fact, interesting because of its closer conformity to the typical diphyodont dentition, is demonstrated by the difference of size of *p* 1 in Pl. III. fig. 4, and the first lower deciduous molar marked *p* 1 in my former memoir, *loc. cit.* pl. 4. fig. 4.

The Hog is the only existing hoofed genus that manifests, as regards number, the typical dentition displayed by the *Dichodon* in common with many other Eocene ungulate and unguiculate Mammalia. The deviation in the Hog from this type is slight, being confined to the non-development of *p* 1, and the early reduction of the numerical formula by the loss of the small tooth, *d* 1, at the beginning of the molar series.

That the *Dichodon* belongs to the Artiodactyle series is inferred, notwithstanding the want of any direct evidence of the structure of its limbs, from the more simple form and structure of *p* 1, *p* 2, and *p* 3, as compared with the true molars, and from the symmetrical ruminating pattern of the grinding surface of the crown of the true molars.

From the true Ruminants the *Dichodon* differs in the development of the upper incisors and of *p* 1 in both jaws, which teeth are wanting in all the known existing species.

Such feeble traces of embryotic rudiments of these teeth as have been observed by Professor Goodsir and others, in the Cow and Sheep, and the more conspicuous germs of upper incisors, of which one pair is functionally developed, in the *Camelidæ*, are phænomena that derive increased significance and interest from the fact of the functional development of the same teeth in Artiodactyle Ungulates of the Eocene period.

In the configuration of the true molars the *Dichodon* would seem to be more nearly allied to the Ruminant section of the *Artiodactyla*: in the number and kinds of its teeth it more resembles the Hog-tribe amongst the non-Ruminant section. The known facts of the deciduous dentition of the *Dichodon* supply an additional test of its affinities, owing to the marked differences in the times and order of succession of the permanent teeth between the Hog-tribe and the Ruminants, at least of the Ox and Sheep.

In these the last true molar cuts the gum before any of the premolars appear, and the canine teeth ('corner-nippers' of the Veterinarians) are the last of the permanent teeth to come into place, their appearance marking the completion of the third year in the Sheep, and a somewhat later period in the Ox. In the Hog the canines appear before the premolars, and these are in place and use before the last molar is on a level with the rest of the grinders.

In the *Dichodon cuspidatus* the second true molar, in the upper jaw, is in place before any of the deciduous series of teeth have been shed; and it is coming into place, with the crown complete, before the pulps of the premolars have even begun to be calcified. The lower jaw of the Sheep at from nine to twelve months would afford the nearest parallel amongst existing Artiodactyles to that of the immature *Dichodon* figured in pl. 4. fig. 2. vol. iv. of the 'Quarterly Journal of the Geological Society.' But by the time the second true molar in the Sheep is as far advanced in development as in the *Dichodon* (fig. 2, *loc. cit.*, *p* 2, upper jaw), the first permanent incisor is in place, and the germs of the premolars in the cavities of reserve have calcified crowns.

I append the subjoined Table, indicating the several teeth by the symbols explained in my Paper on the Homologies of the Teeth*, and in the Article Teeth of the 'Cyclopædia of Anatomy and Physiology,' vol. iv.

The necessity of exactness in the records of the age of the valuable breeds of domesticated cattle, exhibited in competition at Agricultural Meetings, has led to a greater accuracy in the statements of the periods of development of the different teeth in the Ox, Sheep, and Hog, and I have combined the results of my own observations with those recorded by Bojanus, the learned Veterinary Professor at Wilna, and by Mr. Simonds, the Professor of Cattle Pathology in the Royal Veterinary College of London†, in the following

Table of the Times of Appearance of the Permanent Teeth in the

	Ox.				Sheep.				Hog.	
	Early.		Late.		Early.		Late.			
Symbols.	Year.	Month.	Year.	Month.	Year.	Month.	Year.	Month.	Year.	Month.
i 1	1	9	2	3	1	0	1	4 to 8	1	0
i 2	2	3	2	9	1	6	2	0 to 4	1	6
i 3	2	9	3	3	2	3	2	9 to 12	0	9
c	3	3	3	9	3	0	3	6	0	9
m 1	0	4	0	6	0	3	0	6	0	6
m 2	1	3	1	8	0	9	1	0	0	10
m 3	2	0	2	3	1	6	2	0	1	6
d or *p* 1	0	0	0	0	0	0	0	0	0	6
p 2	2	6	2	8	2	0	2	6	1	0
p 3	2	6	2	8	2	0	2	6	1	0
p 4	2	8	3	0	2	3	2	6	1	3

* Philosophical Transactions, 1850, p. 481.

† "The Age of the Ox, Sheep, and Pig," 8vo, 1854.

EXPLANATION OF PLATE III.

(All the figures are of the natural size.)

Fig. 1. Portion of lower jaw with the three true molars, *m* 1, *m* 2, *m* 3, from the outside.
Fig. 2. Crowns of the same teeth, from the inside.
Fig. 3. Grinding surface of the same teeth: *f*, outer cusp or division of the lobes of the first true molar; *a*, *b*, *c*, *d*, *e*, the five internal accessory basal cusps of the internal divisions of the same tooth; *f'*, *f'*, the outer divisions of the two anterior lobes of the last molar; *g*, the outer division of the third lobe of the same tooth.

This specimen is from the Upper Eocene clay of the Isle of Wight, in the collection of Dr. Wright of Cheltenham.

Fig. 4. Part of the upper jaw, showing the working surface of the right incisors, canine, and three anterior premolars, as in their natural position.
4 *a*. Outside view of the third premolar of the same specimen.
Fig. 5. Portion of lower jaw, with the last true molar.
5 *a*. Grinding surface of the same molar.

These specimens are from the Upper Eocene sands of Hordwell, Hants, and are in the British Museum.

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2. *On the* Fossil Vertebræ *of a* Serpent (Laophis crotaloïdes, Ow.) *discovered by* Capt. Spratt, R.N., *in a* Tertiary Formation *at* Salonica*. By Prof. Owen, F.R.S., F.G.S. &c.

[Plate IV.]

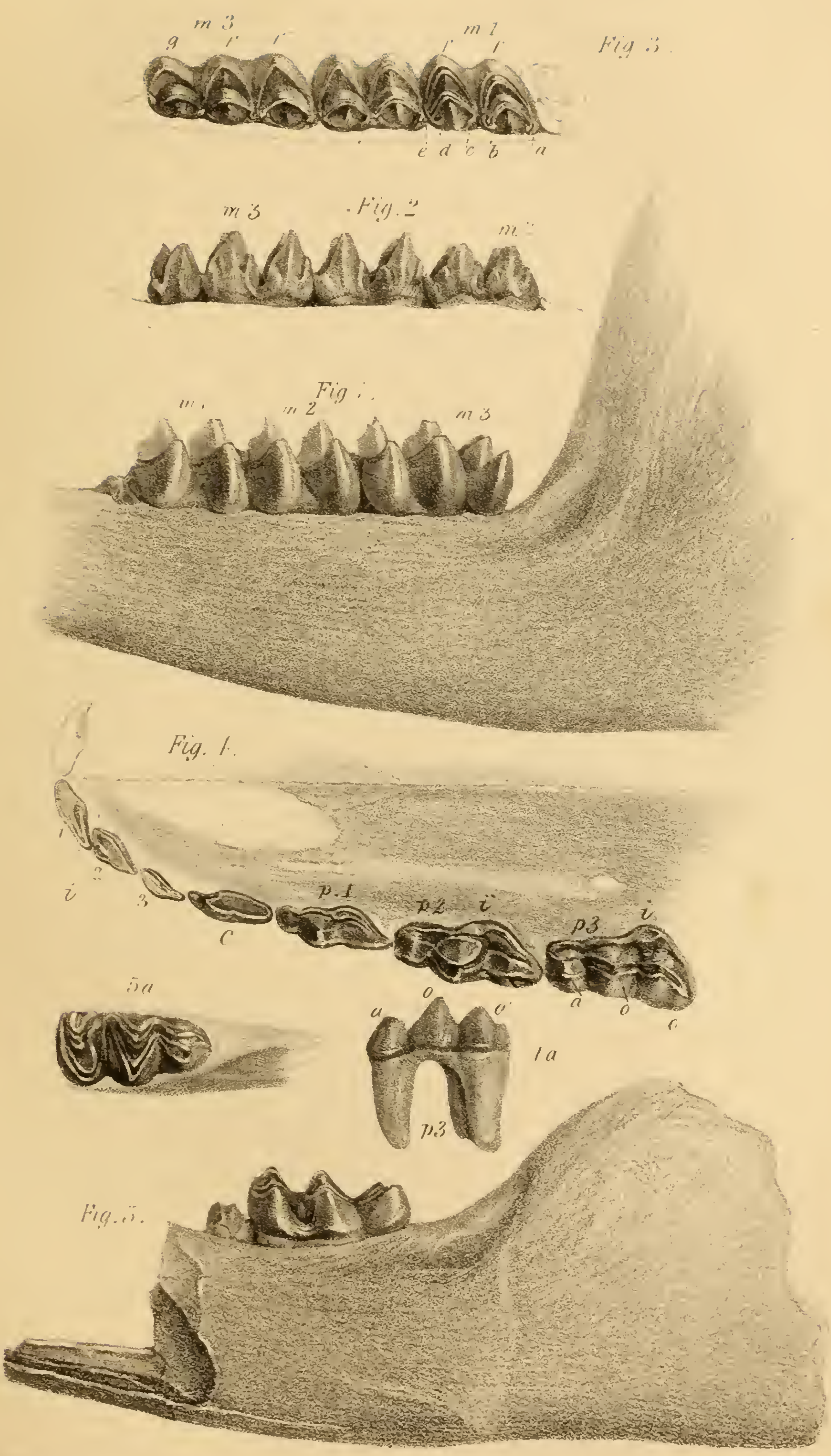
The characters for distinguishing and determining the fossil remains of Serpents are deemed, I believe, by most palæontologists to be less salient and satisfactory than in those of other reptiles. I have found, however, in the course of comparisons called for by the discovery of Ophidiolites in our own tertiary strata, more differentiating characters in Ophidian vertebræ than the works on comparative anatomy gave promise of; and no palæontologist would find a difficulty in distinguishing the vertebra of an eocene *Palæophis* (Pl. IV. fig. 1), *e.g.* from that of any known existing Ophidian, provided the neural arch (*n*, *z*) were entire.

For the nomenclature of the parts and processes of an Ophidian vertebra, and for their chief modifications in existing Serpents, I must refer to my "History of British Fossil Reptiles†," pp. 135–139, *Ophidia*, plates 2 and 3. It will there be seen that in the genera *Python* (figs. 5 and 6), *Boa*, *Eryx*, *Coluber* (fig. 7), *Deirodon*, and *Hydrus*, the hypapophysis (*h*) subsides into a ridge, or a short subcompressed tubercle, in the vertebræ situated behind the anterior third or fourth part of the trunk; but that in *Crotalus* (fig. 4), *Vipera*, and *Natrix* the hypapophysis, *h*, is continued, with more or less diminution of relative length, from all the vertebræ supporting free ribs.

In all the fossil vertebræ of the Serpent from Salonica, thirteen in number, submitted to my examination, the hypapophysis (figs. 2 and 3, *h*), where entire, is developed, of equal length and similar form,

* See above, p. 183.

† See also Monograph of the Eocene Reptiles, Palæont. Soc. 1850, plates 13 and 14.



Dichodon cuspidatus.

from the back part of the under surface of the centrum, and a ridge is continued from the fore-part of its base, gradually expanding as it subsides, to the lower rim of the anterior articular cup of the centrum, below which it makes no projection.

With the small number of vertebræ of this fossil Serpent transmitted for comparison, this character alone will not warrant a conclusion in favour of its affinities to the *Crotalus*, since they may all have come from the anterior region of the trunk, where a similar hypapophysis is developed in the other genera of Serpents above mentioned.

In point of size, the vertebræ from Salonica agree with the middle trunk-vertebræ of a *Python tigris* of 11 feet in length; but they are manifestly of a different genus and family of Serpents.

Independently of the ridge continued forwards from the hypapophysis, there is a process, figs. 2 and 3, *d'*, flattened behind, produced downwards and forwards below and beyond the articular cup, from the under part of the diapophysis, *d*, as in *Crotalus*, fig. 4. A small and well-defined articular tubercle, *d*, projects from near the upper part of the diapophysial surface, also as in *Crotalus*; and the upper part of the diapophysis is produced and bent outwards at *d''*, beneath the anterior zygapophysis, *z*, with which it is blended, and which it seems to sustain, like a cantilever in roof-architecture; the obtuse point of the process extending outwards (fig. 3, *d''*), about a line beyond the flat articular surface of the zygapophysis, *z*. A minute tubercle beneath the outer end of that articular surface indicates the homologous point in *Python*; but the production of the pointed process is not found in any of the vertebræ of the constricting Serpents. It characterizes the vertebræ of the genera *Coluber* (fig. 7), *Naja*, *Crotalus*, and *Hydrus*; and the degree to which the process in question is produced in the fossil Serpent is intermediate between *Coluber*, where it is longest, and *Crotalus*, where it is less developed.

The zygosphene, *zs*, is relatively broader in proportion to its depth in the fossil Serpent (fig. 3) than in *Python* (fig. 6), and is slightly excavated anteriorly, and without a median tubercle; it more resembles the form and proportions of that part in *Coluber* and *Crotalus*. The posterior border of the neural arch, *n*, describes a gentle curve convex backwards as it descends from the base of the neural spine to the posterior zygapophysis, *z'*. The similarly-sized fossil vertebræ of the *Palæophis toliapicus* offer a striking contrast with the Salonica Ophidiolite in the configuration of this part, which is produced into an angle (fig. 1, *n*); the posterior zygapophyses are more produced outwards than in the anterior trunk-vertebræ of *Python*, resembling those of the middle trunk-vertebræ of *Python*, which are without the long hypapophysis. The base of the neural spine is coextensive with the neural arch; no well-defined part of the zygosphene projects beyond it, as in *Python*, *Naja*, and *Hydrus*. In this respect the Salonica Ophidiolite resembles *Crotalus*; the neural spine is more compressed than in *Python*, and its posterior border slopes more backward; but it is not sufficiently entire in any of the specimens to permit this comparison to be pursued with advantage. The process from above the concave part of the expanded articular end of the rib is relatively longer than in *Python*, resembling in its proportions that in *Coluber*; and the articular concavity itself is better defined.

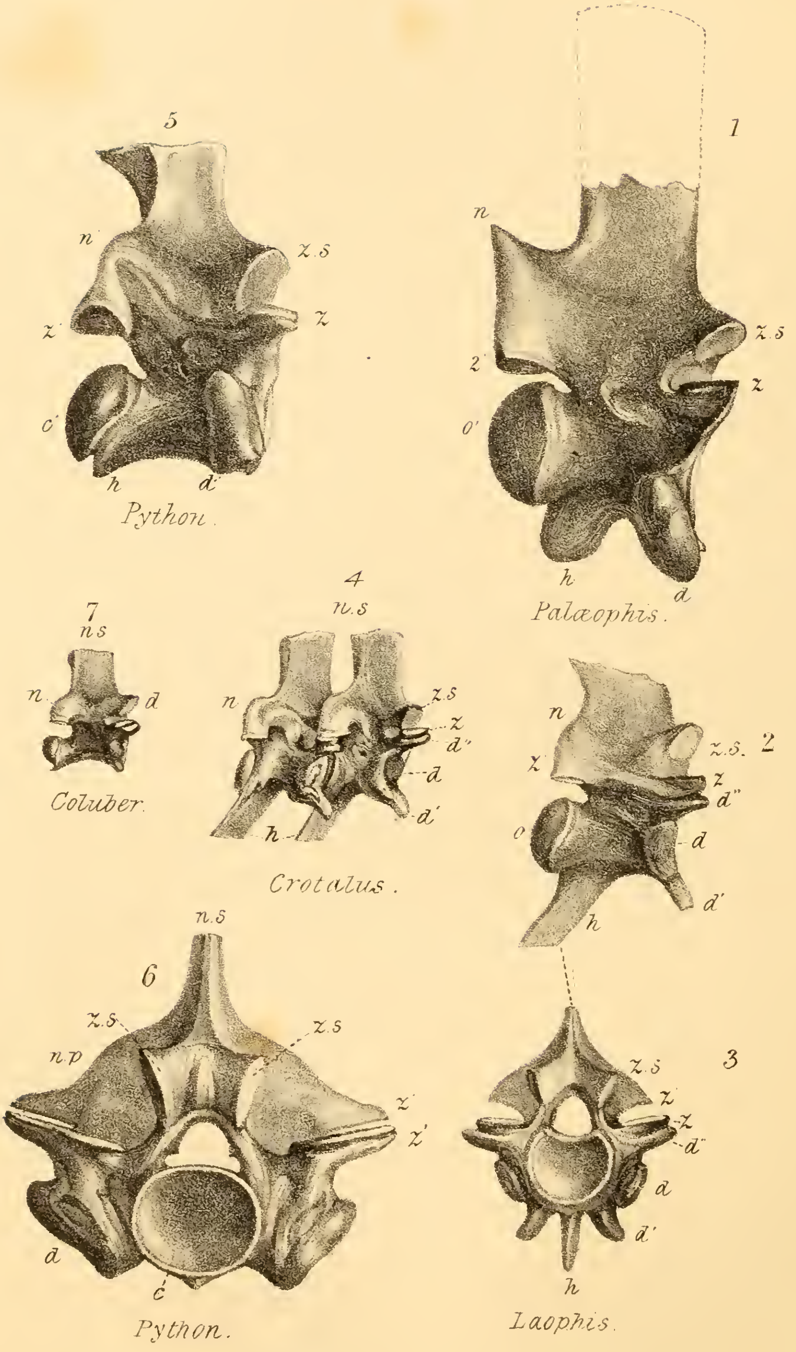
Of the 253 trunk-vertebræ of the *Python tigris*, the 74 anterior ones have long hypapophyses; the remaining 179 have mere tubercles in the place of those processes. If 13 scattered vertebræ of a disarticulated skeleton of such a Serpent were picked up, it is three to one but that they would be of the 179 without the hypapophyses.

In the *Coluber Histrio*, the 58 anterior vertebræ have hypapophyses; the succeeding 157 vertebræ, which support moveable ribs, have no hypapophyses. In the *Deirodon* (*Anodon*) *scaber*, hypapophyses are developed from 32 anterior vertebræ; in the remaining 58 vertebræ with moveable ribs the process subsides to a mere tubercle. In the same proportion of the trunk-vertebræ of an African species of *Eryx*, the hinder end of the hypapophysial ridge is slightly produced. In *Naja*, as in *Viperus*, the hypapophysis is continued, but of relatively smaller size than in *Crotalus*, from the posterior part of the lower ridge of the vertebra throughout the trunk. The diapophysis presents the same well-marked tubercle upon its upper part as in the Rattlesnake, but the lower end is less produced; the process underpropping the zygapophysis projects proportionally further beyond the articular surface.

The probability is in favour of the fossil Serpent from Salonica resembling those genera in which the hypapophysis is well developed from all the trunk-vertebræ; the breadth of the base of the neural arch indicates that they have been from about the middle, not from the fore-part of the trunk. The vertebræ offer so many points of resemblance with those of the Rattlesnake and Viper, that they may have belonged to a venomous species; they are, however, at least, specifically distinct from the vertebræ of known species of *Crotalus* and *Vipera*, and they by no means afford certain grounds for a conclusion as to the poisonous character of the Salonica Serpent.

The known existing Serpents of Southern Europe and Asia Minor include a species of *Eryx* (*Anguis jaculus* of Hasselquist), several subgenera of Colubrine harmless Snakes, e. g. *Ailurophis vivax*, Fitzinger, *Cœlopeltis monspessulana*, Ranz., *Periops hippocrepis*, Wagler, *Zacholus austriacus*, Wagler, *Zamenis Riccioli*, Bonaparte, *Callopeltis flavescens* and *Cal. leopardinus*, Fitz., *Rhinechis scalaris*, Bonap., *Elaphis quadrilineatus*, Bonap., *Hæmorrhoïs trabalis*, Boie, also from four to six species of *Natrix* and of *Coluber* proper; but none of these species now present a size comparable with that of the fossil Serpent from Salonica. Some individuals of the *Natrix viperina* of Dalmatia have been said to reach the length of 6 feet. The poisonous Serpents of the South of Europe and Western Asia are exclusively viperine (*Pelias berus*, Merrem, *Vipera aspis*, and *Vip. ammodytes*, Latr.), but are still smaller in comparison with the fossil.

The classical myth embalmed in the verse of Virgil, and embodied in the marble of the Laocoon, would indicate a familiarity with the idea at least of Serpents as large as the *Laophis* in the minds of the



R. Owen, del.

Day & Son, Lithrs to The Queen

RECENT & FOSSIL OPHIDIAN VERTEBRÆ.

ancient colonists of Greece. But according to actual knowledge, and any positive records of zoology, the Serpent, between 10 and 12 feet in length, from the tertiary deposits of Salonica, must be deemed an extinct species. The fossil may be provisionally indicated as *Laophis crotaloïdes**.

EXPLANATION OF PLATE IV.

Fig. 1. Middle trunk-vertebra of *Palæophis typhœus*, Ow., from the Eocene of Bracklesham, Sussex.
2. Trunk-vertebra of *Laophis crotaloïdes*, Ow., from near the Promontory of Karabournou, on the eastern coast of the Gulf of Salonica.
3. Front view of the same vertebra.
4. Two middle trunk-vertebræ of *Crotalus durissus*.
5. Middle trunk-vertebra of a *Python tigris* 17 feet long.
6. Front view of the same vertebra.
7. Middle trunk-vertebra of the *Coluber Histrio*.

(All the figures are of the natural size.)

c. Anterior articular cup.
o. Posterior articular ball.
h. Hypapophysis.
d. Diapophysis with articular convexity for the rib.
d′. Lower diapophysial process.
d″. Upper diapophysial process.
z. Anterior zygapophysis.
z′. Posterior zygapophysis.
zs. Zygosphene.
n. Hinder border of neural arch.
ns. Neural spine.

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3. *On* Annelide-burrows *and* Surface-markings *from the* Cambrian Rocks *of the* Longmynd†. No. 2. By J. W. Salter, Esq., F.G.S., and of the Geological Survey.

[Plate V.]

In a former communication (March 1856) I described a few obscure traces of animals from these old rocks in the Longmynd, and have now to add some further information, gathered during the last summer in the same locality.

The markings which were in that paper referred to the burrows of Annelides have been found in the greatest profusion, and through a much greater thickness of strata than before, not less than a mile in vertical measure; and they have been detected too in places considerably to the south and west of the localities before given.

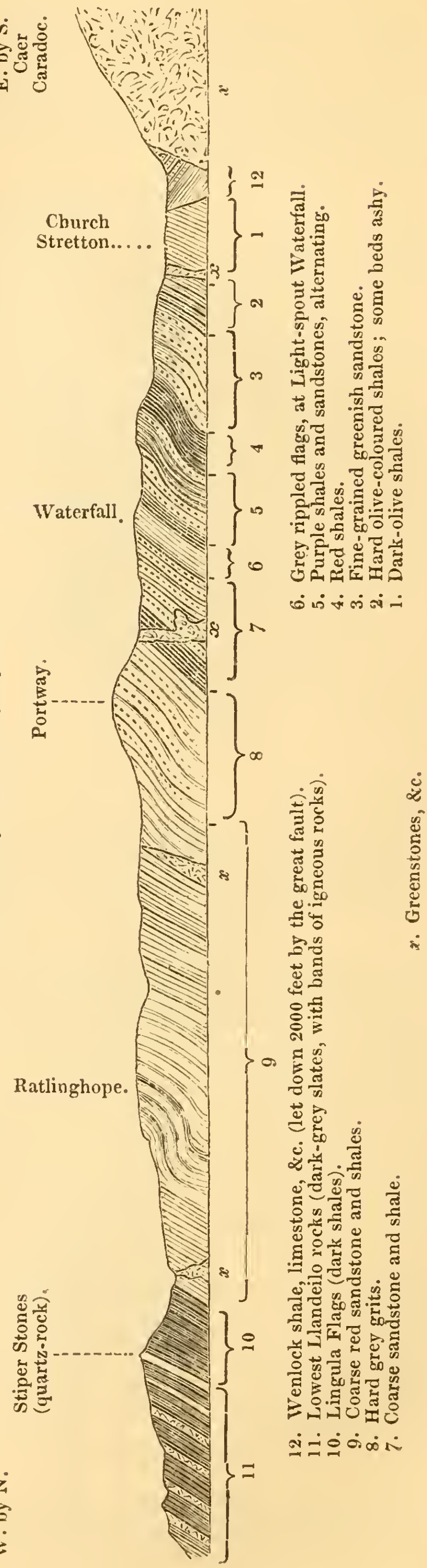
I am glad of the opportunity of again drawing attention to the subject, partly because the woodcut-section in the former paper, at page 247, Journ. No. 47, was accidentally made so as to exclude the most important beds, and partly because these annelide-markings have, during the present year, been sedulously searched for, and similar ones found, by my friend, Dr. J. R. Kinahan, of Dublin, in the undoubted Cambrian beds of Bray Head, Wicklow. His paper

* Gr. λᾶας, a stone, ὄφις, a serpent.

† For the former communication on Fossil Remains in the Cambrian rocks of the Longmynd, see Quart. Journ. Geol. Soc. vol. xii. p. 246.

appeared in the January Number for 1857 of the Proceedings of the Dublin Geological Society.

The section here given has numbers corresponding to the beds enumerated in the former paper; and the overlying Silurian strata (10, 11, 12) are introduced to show their relations to the highly inclined Cambrian beds under notice.



Section of the Longmynd.

No. 1. The dark-olive shales have not yielded any trace of fossils; but in one place the harder beds of the same series, which are designated No. 2, have traces of the *Arenicolites didymus*.

No. 3. The same fossil (*A. didymus*) was found in the lower part of the Oakham Dingle, considerably below the beds in the Carding-mill Brook, from whence it was figured before. Of their existence at this place there can be no doubt.

The higher parts of No. 3 were carefully searched by myself and an assistant (Mr. John W. Rhind), and yielded an unexpected abundance of the worm-burrows, both large and small. The best localities appear to be at the head of Oakham Dingle, where the brook* flows N.E.–S.W. on the strike of the beds, and also along the same line in the next valley, viz. on the west side of Yearling Hill, on the brook that flows down to the "Ashes." The latter locality was very prolific, and nearly all our best

* This brook (of clear sparkling water, like all the "gutters" of the Longmynd) is intended to yield a water-supply to the town of Church Stretton.

specimens came from thence. There are evidences of the burrows of *Arenicola* (*Arenicolites*), of a different species from that formerly described, and it occurs both of large and small size. They are found on the wave-marked surfaces in the greatest profusion, hundreds of burrows being often crowded in the space of a square inch; or they are more widely set and of a larger size, when they frequently are placed most distinctly in pairs, indicating the exit- and entrance-holes to the burrows.

We have evidence in these beds too of the action of the waves in obliterating the burrows; and in fig. 1, Pl. V., may be seen a not unfrequent case, where the rasping action of the surf has only spared those burrows which lay in the shelter of the ripple-hollows.

That the strand was a level shore left dry at low tides, and that the surface was dried by the sun, is abundantly shown by the innumerable sun-cracks (figs. 9 & 10) which traverse the surfaces. These cracks when broad, as they often are, reveal the lighter-coloured sand beneath the filmy coating of dark mud on which the Annelide holes show themselves. There are, besides, rain-prints in abundance on some of these surfaces.

No. 4. The same phænomena, at least the wave-marks and the annelide-holes, are observable in the bands of red slate which overlie the beds No. 3; scarcely a fragment could be broken in the rocky knolls a little above the Carding-mill without showing them in profusion. It is the same further north in the Batch valley, and southwards in several localities, even as far as Choulton bridge, on the Onny River.

No. 6. Again, in the hard, grey, and rippled beds of Light-Spout Waterfall, mentioned in the former paper, Mr. Rhind found the annelides.

In a journey across the eastern portion of the Longmynd, in company with my friends, Messrs. Lightbody and Cocking, of Ludlow, we found them at intervals all the way, until they ended with the sandstones of the Portway itself. The total thickness, therefore, of the fossiliferous beds cannot be less than a mile, as above stated.

In one particular we have been unfortunate. No further traces of the crustacean called *Palæopyge* (vol. xii. pl. 4. f. 3) have been met with, though they were diligently sought for in the locality which produced them last year. I do not on that account consider there is any reasonable doubt as to the nature of the fossil. I have shown it to many scientific observers, and all agreed that it was organic: the evidence therefore remains as before.

Wave-marks and (Wind?) Ripples. Pl. V. figs. 5–8.

The marks of tidal flows or currents are very numerous and perfect, generally in broad hollows and elevations, but occasionally in quite regular transverse ridges which alternate or inosculate, as they do now on the sea-shore (fig. 5).

Besides these larger undulations, the surface is frequently rippled by smaller and finer ridges, which either represent the quiet action of the surf on a level strand, or possibly the agitation of the water by wind: both causes may have operated (figs. 6, 7). I prefer the first explanation, because there are so many instances in which the direction of the lines of surf can be easily traced; and the interference of one small current with another is often apparent in the intersection of these sets of lines (fig. 8). They appear generally to have been slight ridges, and the subsequent compression of the rock has changed them into sharp-edged tabulæ, and the furrows into narrow depressed lines. It is to these wave-ripples, or surf-lines, as they may be called, that I would now refer some of the markings which before I thought were drainage-lines or runnels* (*loc. cit.* pl. 4. f. 5). The specimens at command then were far less perfect than those since obtained, and much more altered by pressure. To any one familiar with the mode in which the tide creeps in or out among the ripple-hollows on a very level strand, this explanation will not be deemed unsatisfactory. Many specimens show the direct action of the water producing straight, close, transverse ridges, and fig. 8 shows the contending currents, caused probably by slight obstructions, which were poured into the hollow in various directions during the advance or retreat of the tide.

In some cases the holes of the burrowing annelides have modified the shape of the surf-ripples, in others they have been modified by them.

Sun-cracks. Pl. V. figs. 9 & 10.

These were most unexpectedly found in great plenty on the west side of Yearling Hill. The rock there is closely laminated, a hard green flagstone of exceedingly fine grain (almost flinty), and the rippled surfaces are covered with a filmy coating of dark-brown oxide of iron.

The sun-cracks do not differ to any great extent from those ordinarily met with in newer rocks (the Permian of Coventry, for instance). They divide the surface into areolæ of various sizes and shapes (fig. 9); and when, as is most common, the superficial layer of mud is darker than the stone, show themselves well in relief by exposing the lower stratum. The edges of the areolæ are most generally curved upwards, the heat of the sun having caused shrinkage. Sometimes this is so much the case, that casts of them in relief, having a semicylindrical form, and cut across by other smaller cracks, look very like jointed portions of Crustacea; and the resemblance is heightened by frequent tubercles, which are the projecting casts of the annelide-holes above noted.

Rain-prints. Pl. V. figs. 1 & 10.

If the ripple-marks and the marks of shrinkage from sun-drying be preserved upon these old surfaces, it is not unlikely that rain-prints should be also present; and accordingly numerous traces of the action

* Not, however, those with branched or dichotomous furrows; they must still be considered as drainage-lines.

of rain have been observed, which appear to be quite the same as those we meet with at the present day, or in strata newer than those under consideration.

The traces consist,—1st, of numerous scattered impressions of drops of large and small size (fig. 10), intermingled upon the rippled and sun-dried surfaces of half-a-dozen specimens from a particular bed; 2ndly, of a close set of prints, more uniform in size, upon another surface; 3rdly, of numerous marks of drops occurring upon a ripple-marked slab, which shows too the annelide-holes in part abraded by the surf, or sheltered in the hollows (fig. 1).

In the first series we have round, or slightly oval, well-marked hollows, with a raised border, more conspicuous on one and the same side in all the prints than on the other. They indicate a somewhat slanting direction for the rain, an inference strengthened by the elongated form of the prints in that direction. In fact, the phænomena so well explained by Sir C. Lyell in his Manual (5th ed. p. 384) are here repeated. The drops were of irregular size; some, much larger than the rest, having apparently fallen after the smaller ones had impressed the surface, and having nearly obliterated their impressions. In other cases, two or three drops of more equal size have fallen nearly on the same spot, and made a compound impression.

These rain-prints are at first sight not easy to distinguish from the larger annelide-holes. But, besides that they are not in pairs (a very important point, since all the annelide-burrows show this character distinctly), there is a marked difference in the regular even outline and clean hemispheric impression of the rain-print, and the less regular shape and uneven bottom of the half-filled burrow. In rare instances the two occur on the same slab.

The prints upon the abraded surface (fig. 3) are somewhat different, much shallower, and closer together, and frequently impressed the one over the other. In this case the rain appears to have fallen vertically and on a harder surface than in the other case; and the bottom of the hollows is flat or occasionally slightly raised in the middle, a character usually considered decisive of rain-prints.

Organic Remains.

The new species of *Arenicolites* above mentioned I propose to designate

Arenicolites sparsus, sp. nov. Pl. V. figs. 1–4.

Sp. char. A. gregarius, fodinarum oribus circularibus binis, sese remotiusculis.

Junior (figs. 1 & 4), fodinis minutis, aggregatis.

Major (fig. 2), fodinis $\frac{1}{2}$-lineam latis, sparsis.

These burrows of annelides, once recognized, are to be found in great profusion, chiefly on the surface of the finer sandstones or shales. The larger ones are more scattered, nearly a line broad, and with the edges of the holes a little raised. They are most distinctly in pairs, often not more than a line apart, but sometimes a quarter of an inch from one another.

The smaller ones (fig. 4) are in myriads close together, but still plainly in pairs. They occur on the same surfaces with the larger ones, but still oftener are met with in groups; all of the same size, or nearly so (about the size of a pin's head), and particularly on the red shales before mentioned. On the upper surfaces of the beds they are, of course, depressions (fig. 1); on the lower surfaces casts of them project (fig. 4) as tubercles.

It is a very common thing to meet with them only in the hollows of rippled surfaces, the wave having erased them on the more elevated portions. Sometimes this occurs in the most distinct and marked manner (fig. 1).

This species appears to be distinct from the so-called *A. didymus* of the former paper, by the holes being remote, not close together nor parallel to each other. They occur rather higher up in the series too; but it is, of course, possible that all may be one species.

Localities.—The small variety has a very wide distribution, as before stated. The larger ones are found in tolerable plenty in Oakham Dingle, at Yearling Hill, the Packet Stone, Minton, and at the Light-Spout Waterfall above Church-Stretton.

It does not appear necessary to insist on the value of such numerous though imperfect vestiges of the oldest fauna known. I am perfectly convinced that the Cambrian rocks contain treasures yet to be discovered, and that a holiday spent at the rising town of Church Stretton would be well rewarded, and might produce new facts for science.

I lately found that burrows similar to the above-described, but of a much larger size, were common in the Stiper Stones of Shropshire; and these bear the strongest resemblance to the long vertical tubes described by Hall under the name of *Scolithus linearis*.

It is almost certain that these are identical; but, as the name *Scolithus* does not convey any definite meaning, there can be no objection to the term *Arenicola*, as used by Binney, who first explained the nature of these double holes. Perhaps the termination *-ites* would make the name more symmetrical with other terms of general import, and *Arenicolites* might stand for all worm-burrows with double openings, while *Scolithus* or *Scolites* might be retained for those which appear to be single tubes or burrows, vertical or horizontal*.

Cololites has long been in use for worm-casts on the surface, and perhaps *Helminthites* would answer best for those long sinuous tracks upon the surface, usually considered as referable to Annelides. *Vermiculites* has been applied to shorter forms†. Some of these, however, are unquestionably trails of small Crustacea, and others of spiral shell-fish.

* *Foralites* has been used by M. Rouault for this kind of burrow. See Bull. Soc. Géol. Fr. vol. vii. 1850, p. 742.

† Ibid. *l. c.* p. 744.

In connexion with the facts above mentioned, which go to show the great prevalence of Annelides having the same habits as those of the Lob-worm (*Arenicola*) of our coasts, it is worth while to remark on the extraordinary abundance of animals of this class in Palæozoic times.

In the Cambrian rocks of Ireland they are in almost as great plenty as in Britain, and are there associated, as I have seen in company with Dr. J. R. Kinahan, who discovered them, with the matted layers of *Oldhamia*.

In the Lingula-flags of North Wales, *e.g.* near Maentwrog and Ffestiniog, they abound wherever sandy sediment has been thrown down; but I have only yet seen them in the form of *Scolites* or *Helminthites*, and have not yet found the double burrows in this formation.

In the Stiper Stones, as above noted, the *Arenicolites* (*Scolithus*) *linearis* of Hall is the common fossil, occurring as long vertical tubes with trumpet-shaped openings in the quartz-rock. And in the Tremadoc slates, the Llandeilo flags, and indeed all the Silurian series, worm-tracks and burrows are frequent in strata which were once sabulous mud. In the Upper Silurian rocks of Dingle, County Kerry, I found the *Arenicolites* in flaggy sandstone.

More lately these double burrows have been found in company with fragments of land-plants in the Devonian fish-beds of Caithness, and in those beds, of somewhat doubtful age, which Prof. Nicol has described as carboniferous, on the borders of Loch Assynt in Sutherlandshire*, while they have now been long known as most plentiful in the sandstones of the coal-measures.

It is in the Carboniferous system, indeed, that they appear to have attained their maximum in size and number. Throughout all the lower beds of that system, as exhibited in Pembrokeshire, North Devon, or the South of Ireland, the burrows of marine worms are conspicuous, chiefly in the form of cylindrical masses, *upon the surfaces* of the beds or permeating them in all directions. They are of various sizes, from the thickness of a crow-quill up to 2 or 3 inches in diameter! and often of great length; and they frequently constitute of themselves massive beds, the sabulous matter left behind as ejected from the worm penetrating the more argillaceous beds in a way that produces an exceedingly tough mass—not easily acted upon by the waves—in shore-sections.

The large annelide-tubes or casts in the carboniferous strata of Cumberland, and the tracks upon the coal-measure flags at Kilkee, County Clare†, are well known, and are of a size greatly larger than would be produced by the majority of living species. There is much yet to be done in the study of marine worms, with a view to ascertain the kind of impressions they leave in both sandy and argillaceous sea-beds.

* Quart. Journ. Geol. Soc. No. 49. p. 32. The arrangement of these burrows appears to have led Prof. Nicol into the belief that he had found fragments of *Stigmaria*, and may have influenced him in determining the age of the beds.

† Edinb. New Phil. Journ. new ser. vol. i. p. 278.

EXPLANATION OF PLATE V.

(The specimens are reversed in the lithograph.)

Fig. 1. Rain-prints on rippled surface, with Annelide-burrows (*Arenicolites sparsus*; young) in the hollows of the ripple.		From Yearling Hill, Church Stretton.
2. *Arenicolites sparsus* (adult); on the upper surface of the slab.		
3. *Arenicolites sparsus* (adult);	raised casts of the burrows, on the lower surface of the slabs.	
4. *Arenicolites sparsus* (young);		
5. Rippled surface.	Waterfall, above Church Stretton.	
6. Rippled surface.		
7. Rippled surface.		
8. Surf-ripple on current-marks.	Yearling Hill.	
9. Sun-cracked surface.		
10. Rain-prints and sun-cracks.		

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4. *On some species of* Acidaspis *from the* Lower Silurian Beds *of the* South of Scotland. By Wyville Thomson, LL.D., F.R.S.E., Prof. Geol. Queen's Coll. Belfast, &c.

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

[Plate VI.]

Having occupied part of my leisure for the last year or two in examining the fossils of the Silurian beds of the south of Ayrshire, described by Sir Roderick Murchison in 1851, I have met with many species and not a few generic types additional to those included in Mr. Salter's list accompanying Sir R. Murchison's paper on the Silurian Rocks of the South of Scotland*. As most of the known British species of the genus *Acidaspis* have either been already described or are now in process of description, I take an opportunity of adding the few new forms which have hitherto occurred during the course of my investigations.

The specimens are few, and in many cases fragmentary. The first two species are an addition to a little group already represented among our Lower Silurians by *Acidaspis Jamesii* and *A. bispinosa*. The group is formed of minute species, usually rather meagrely ornamented, and having a tendency to the fusion of the various prominent parts of the head; a tendency which reaches its maximum in the subgenus *Trapelocera*, between which subgenus and *Acidaspis* proper (represented by *A. mira*, Barrande, and *A. Brightii*, Murch.) this group may be considered a link.

Acidaspis Lalage, sp. nov. Pl. VI. figs. 1–5.

A. lata, ovata; capite brevi, transverso; glabellâ triangulari, utrinque duobus lobis lateralibus ovatis, a lobo mediano cerviceque alto, et a

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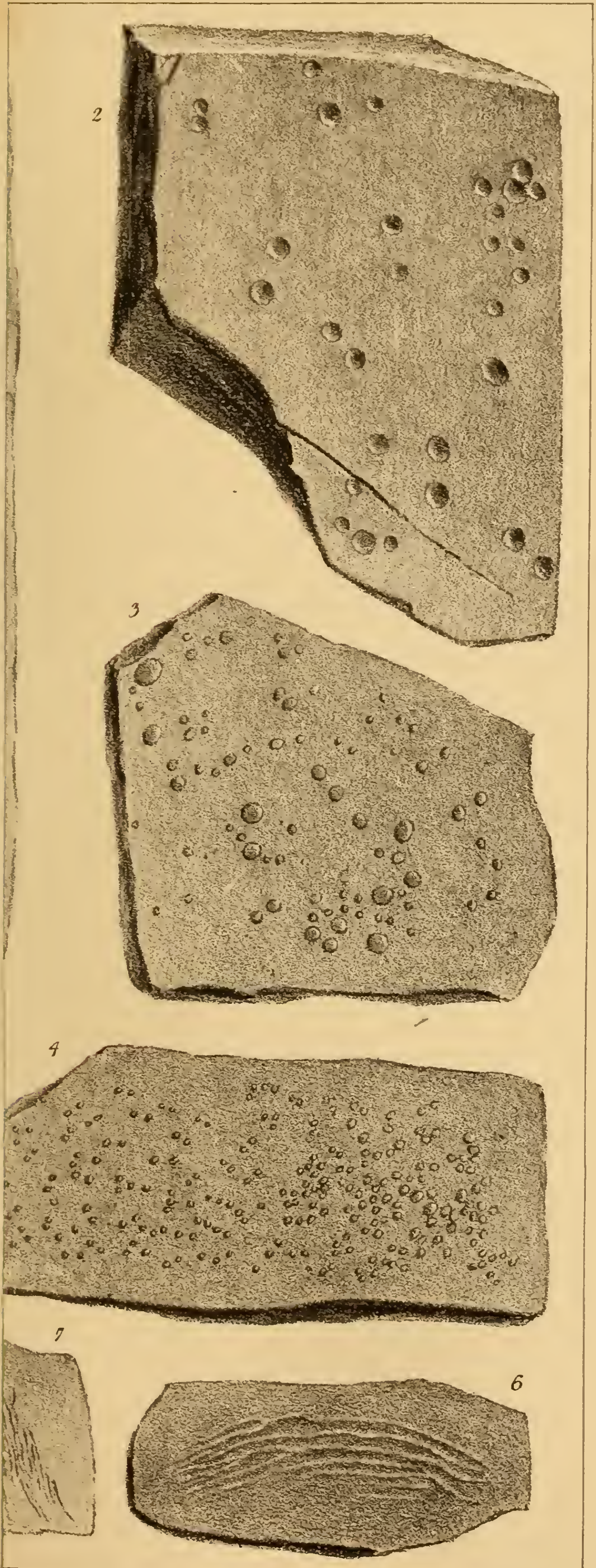
* Quart. Journ. Geol. Soc. vol. vii. p. 137. I shall not enter into a consideration of the detailed section of the district at present. Following Sir R. Murchison, I regard the whole of the fossiliferous Girvan beds as belonging to the very top of the Lower Silurians. The Pinwhapple flags, however, I consider to be the lowest of the series, equivalent to the Upper Bala, and passing through the Mullock Hill sandstone and the Craighead limestone into the Saugh Hill sandstone = Upper Caradoc.



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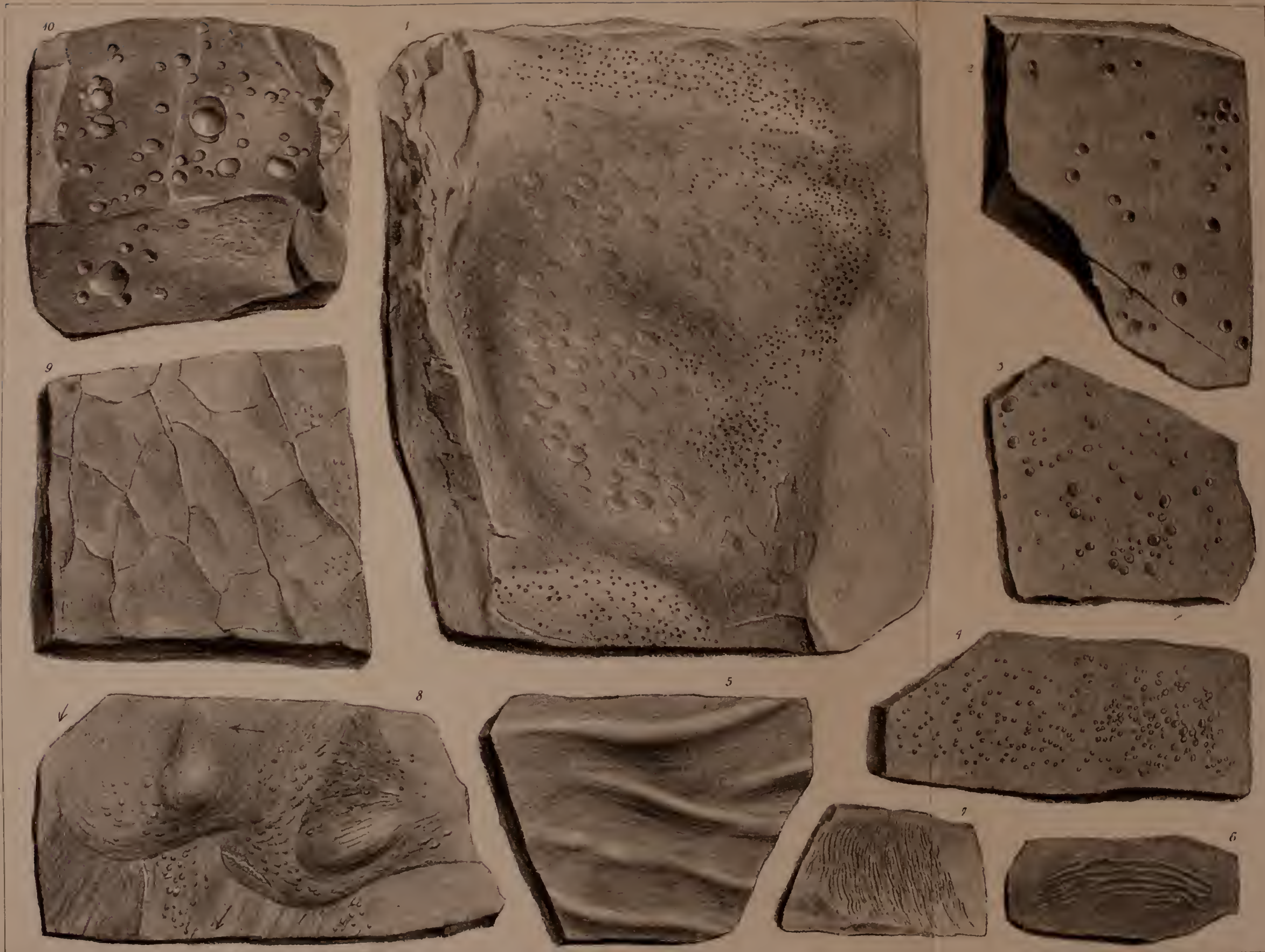

ANNELIDE-BURROWS & SURFACE-MARKINGS
from the Longmynd Rocks

genis parum profundo sulco sejunctis; cervice gibbo, retrorsum elongato, bispinoso; thorace segmentis novem, unispinosis; capite pleurisque leviter granulosis, adspersis hic et illic tuberculis minutis; caudâ brevi, transversâ, semilunari; testâ reticulatâ, margine quatuordecim spinis radiantibus, æqualibus, ornatâ.

Not above half an inch long. General form broad, rather square. Head broad and short. Glabella triangular; median lobe broad, not very prominent. Two oval side-lobes entirely circumscribed, separated from the median lobe by distinct furrows.

Portion of the cheek within the facial suture very gibbous. Ocular ridge distinct. Eyes somewhat remote.

Neck-segment separated from the median lobe of the glabella by a shallow groove; gibbous, and continued backwards into two long, diverging, straight or curved spines.

Axis of thorax and abdomen narrow, prominent.

Body-rings nine; lateral portions horizontal, convex; a longitudinal furrow separates the convexity into two ridges, which coalesce at the distal extremity, and end in a long, slightly recurved spine.

Tail short, semicircular, of two short segments, fringed with from twelve to fourteen long, radiating, equal spines; a ridge from the anterior axis-segment is continuous with the antepenultimate spine on either side.

General surface of the head and body-rings slightly tubercular; surface of tail reticulated.

The form of the tail of this species at once distinguishes it from all its British congeners, as indeed from all species hitherto described, with the exception of *A. radiata*, Goldf., which it closely resembles. The tail-spines of the present species are longer than in *A. radiata* and slightly curved. The reticulation on the surface of the tail is not brought out in the figures of *A. radiata*.

If Barrande's identification be correct, *A. radiata* must extend upwards into the Devonians. A very slight distinction would, I think, authorize us in denying so wide a range to a Lower Silurian form.

Locality.—Rather common in schists at the base of the "Graptolite and Orthoceratite flags," Pinwhapple Glen, Ayrshire, = Upper Bala.

Acidaspis hystrix, sp. nov. Pl. VI. figs. 6–10.

A. angusta, ovata, testâ tuberculis minutis perornatâ; capite brevi, transverso, glabellâ triangulari, lobo mediano longitudinali, utrinque duobus lobis lateralibus, ovatis, a genâ loboque mediano sejunctis; posteriori lobo laterali cervice gibbo coalescente; thorace pleuris novem bispinosis; caudâ latâ, brevi, spinis duodecim æqualibus, parallelis, reflexis, fimbriatâ.

Less than half an inch long.

Glabella broadly triangular, not very highly arched; middle lobe rather narrow; lateral lobes two, oval, separated by distinct grooves from the central lobe and from the cheek; *basal lateral lobe fused with the neck-segment*. Portion of cheek within the facial suture very gibbous, *likewise confluent with the neck-segment*. Neck-segment very prominent, separated from the middle lobe of the glabella by a shallow groove.

We have only one specimen of this species, showing the head. The anterior portion is imperfect, so that the position of the eyes and the development of the ocular ridge cannot be determined. The free part of the cheek is also absent. As in its near neighbours, the neck-segment was probably prolonged and spinous; but this portion is likewise injured. The head is densely ornamented with tubercles.

Axis of thorax and abdomen narrow and prominent. Body-rings nine; lateral portion of body-ring horizontal, convex, with a groove running along it, somewhat nearer the anterior than the posterior margin, and dividing the surface into a narrower anterior and a broader posterior ridge, the posterior ridge terminating in an abruptly reflexed, slightly curved spine, nearly one-third the length of the body, and the anterior in a smaller spine, less abruptly reflexed, and so placed as to pass below the posterior spine of the segment before it.

Tail minute, short, and as wide as the body-rings; axis of two very convex segments, margin fringed with twelve *parallel or slightly approximate equal* spines. A ridge runs from the first axis-segment on either side continuous with the antepenultimate spine, indicating the primary spine, the posterior spine of the anterior tail-segment. The surface of the body-rings and tail is richly granular.

This is a pretty, little, distinct species; the head, body-rings, and tail are nearly equal in breadth, so that the contour of the animal is more regularly a parallelogram than usual. The granulation is peculiarly rich, and the long, curved, nearly adpressed spines are graceful.

A. hystrix does not very closely approach any described species. It somewhat resembles *A. Prevosti*, Barr. The structure of the head and the number and arrangement of the tail-spines distinguish it.

Locality and Geological Position.—Tolerably common in schists forming the base of the "Graptolite and Orthoceratite flags," Pinwhapple Glen, Ayrshire, = Upper Bala.

Acidaspis callipareos, sp. nov. Pl. VI. figs. 11, 12.

A. capite magno, transverso, semilunari; scuto centrali fere quadrato, sed antice aliquanto angustiori; glabellâ magnâ, tumidâ, utrinque lobis lateralibus binis, postico majori, oblongo, antico ovato, sulcis circumseptis; genâ convexâ, declivi, margine duodecim circiter stylis parallelis pectinatâ, postice in spinam fortem productâ; cervice lato, gibbo, (bispinoso?). Thorace —? Caudâ —?

We are only acquainted with the head of this beautiful species, which is semicircular and very highly arched. It is $\frac{4}{10}$ths of an inch wide, and belonged to a larger species than either of the foregoing.

Glabella nearly square, the square defined by the distinct ocular ridge. Side-lobes two, oval, the posterior pair much larger and wider than the anterior; middle lobe wide and fully arched. Eyes far back in the head, and rather approximate. Portion of cheek without the facial suture, passing nearly perpendicularly downwards from the ocular ridge, ornamented with a beautiful fringe of long parallel spines, and prolonged into a long, curved, genal spine.

From our specimen, it appears that the neck-segment is evidently prolonged, but it is unfortunately broken off before reaching its spinous armature. Head richly granular.

Locality.—Mullock Hill sandstone, Girvan, Ayrshire. I believe this sandstone to be an equivalent of a portion of the Upper Bala group still higher than the "Graptolite and Orthoceratite flags." In mineral, and to a certain extent in palæontological, character it seems to pass into the Saugh Hill sandstone, which is rich in the typical Caradoc forms, *Encrinurus punctatus*, Brün. sp., *Cyphaspis megalops*, M'Coy, sp., *Pentamerus oblongus*, Sow., *Atrypa hemisphærica*, Sow., *Tentaculites annulatus*, Schloth., *Beyrichiæ*, &c.

This species is evidently closely allied to *A. pectinata* of Angelin; indeed we must put great faith in the correctness of the figure in the 'Palæontologia Scandinavica,' to draw a distinction between them. The general form of the glabella is the same in each. In *A. callipareos* the posterior lateral glabellar lobe is much larger than the anterior; in *A. pectinata* the lobes are represented as nearly equal. This is unusual, and might prove a fallacy arising from some imperfection in the specimen figured.

Both species are closely allied to *A. Dama*, Fletcher and Salter, MS.*; but in *A. Dama* the eyes are much more remote than in *A. callipareos*, and the head is altogether broader and shorter, more allied in general form to *A. Brightii* and the *A. bispinosa* group.

The outline of the head of the present species is more like that of *A. Dormitzeri*, Barr., than of any described British form. The eyes in *A. callipareos* were pedicellate.

A. callipareos closely resembles *Ceraurus* (*A.*) *crenatus*, Emmerich, especially Lovén's figure in the Stockholm 'Öfversigt.' It is distinguished from it by the narrowness of the anterior triangular space within the ocular ridge.

Acidaspis unica, sp. nov. Pl. VI. figs. 13, 14.

A. segmentis duodecim, tuberculosis, unispinosis, antice latis, postice angustioribus; caudâ minutâ, bisegmentatâ. Capite —?

Head wanting. The entire form, including the tail-spines, must have been $\frac{3}{4}$ inch long. Body-rings twelve; lateral portions horizontal; a double ridge runs along the lateral portion of each segment, the two ridges coalescing at the distal extremity, and ending in a strong, long, reflexed spine; the spines nearly uniform in length. Axis of body-rings very convex. Axis and lateral portions ornamented with a double row of minute granules.

Tail short, consisting of two minute segments. Lateral appendages of first segment slightly expanded, twisted backwards at a right angle about $\frac{1}{4}$th of their length from the axis. A shallow groove passes through the centre of the slightly granulated expanded portion. The appendages of the second tail-segment are lost; they probably supported a fringe of short equal spines.

* Morris, Catal. Brit. Foss. 2nd edit. p. 99.

Locality.—Schists at the base of the "Orthoceratite and Graptolite flags," Pinwhapple Glen, Ayrshire, = Upper Bala.

There can be no doubt, from the style of armature and ornament, and from the general appearance of this form, even without the assistance of the head, that it belongs to the genus *Acidaspis*. The structure of the tail is that of *A. Keyserlingi*; only the ridge, which usually traverses the pygidium, and joins or forms the primary spine, is still farther expanded at the expense of all the flat portion of the appendages of the first joint of the tail-axis.

Only ten body-rings have hitherto been noted in any species of *Acidaspis*, and nine is the more usual number; the number twelve, therefore, in this species, is a singular characteristic. *A. unica* forms a very welcome link between *Acidaspis* and the *Cheiruridæ*, already in many respects closely allied.

None of the species of *Acidaspis* described in former works have hitherto occurred in the Silurian rocks of the South of Scotland.

EXPLANATION OF PLATE VI.

(The specimens are reversed in the lithograph.)

Figs. 1–5. *Acidaspis Lalage*. 1–4. Twice the natural size. 5. Much enlarged. From specimens in my own collection.

Figs. 6–10. *Acidaspis hystrix*. 6. Much enlarged, from a small specimen. 7, 8. Twice the natural size. 9. Much enlarged. 10. Represents the supposed arrangement of the double row of spines. The specimen fig. 8 is from the Survey Collection; the others are from my own.

Figs. 11, 12. *Acidaspis callipareos*. 11. Partially restored, and twice the natural size.

Figs. 13, 14. *Acidaspis unica*. 13. Twice nat. size. 14. Much enlarged.

Figs. 15–17. *Acidaspis Caractaci*. 15, 16. Natural size. 17. Much enlarged.

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5. *On two* Silurian Species *of* Acidaspis, *from* Shropshire. By J. W. Salter, F.G.S.

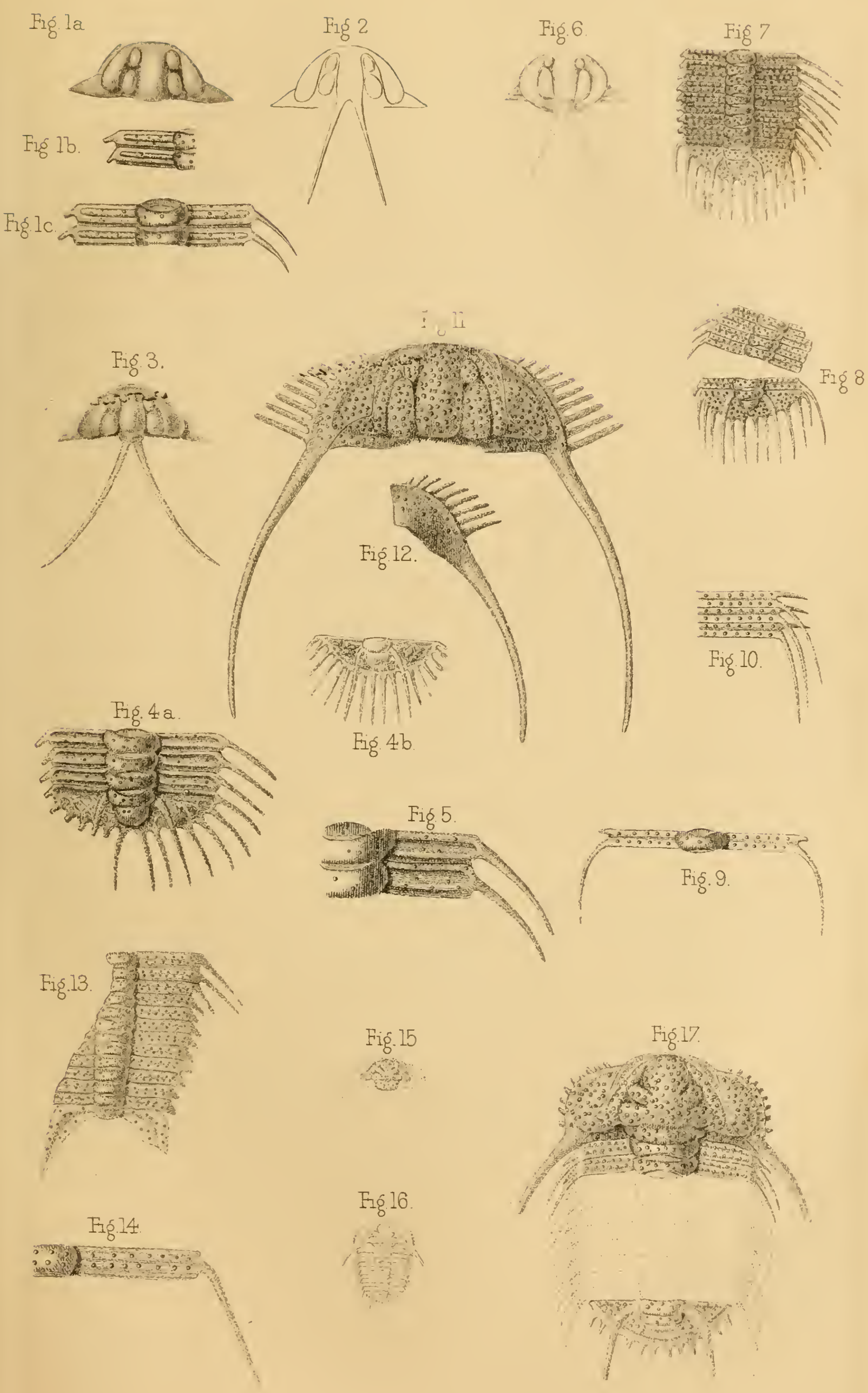
[Plate VI. figs. 15–17.]

I take the opportunity afforded by my friend Dr. Thomson's paper, to add a figure to his plate, and a notice of two species, which will help to complete the account of the genus. They have been previously quoted in the second edition of Morris's Catalogue; but one has not been figured, and the other not described.

1. Acidaspis coronata, sp. nov.

A. Brightii, Salter, Mem. Geol. Surv. vol. ii. pt. 1. p. 348. pl. 9. figs. 8 & 9 only; *A. coronatus*, Salter, Morris's Catal. 2nd ed. p. 99.

A. lata, ferè uncialis, capite angulis latis productis, nec a genis abruptè distinctis: glabellâ angustâ; lobis sejunctis,—basalibus medianum æquantibus: cervice mutico?: oculis parvis retrorsum tractis: caudâ transversâ brevissimâ, spinis 8,—primariis modicis, terminalibus 4, externis utrinque 1; omnibus parallelis.



ACIDASPIS.

G. West lith. W. West Imp.

The head is semilunar, an inch wide, the front margin much arched, its outer angles scarcely at all quadrate, and with about eleven or twelve notches or short spines. The glabella is an equilateral triangle, very prominent, narrowly obovate, and not at all fused with the cheeks; the basal lobes large and circumscribed, the second pair rounded, the uppermost (as in all this section of the genus) wanting.

The ocular ridges are narrow and distinct, diverging at an angle of about 90°, and the intermediate lobe (between these and the glabella) narrow, very prominent below, but not quite so broad as the basal glabella-lobe. Eye small, placed far back, as in *A. Brightii*. The posterior angles of the head are narrowed gradually into the spine, which is oblique and continuous in direction with them, not abruptly turned outwards.

The tail much resembles that of *A. Brightii* and other species, in which the primary spines do not differ greatly in size from the rest. They are directed exactly backwards, or even converge a little; there are four terminal equidistant spines between them, and one outside each. The axis is short, and the general shape of the tail shorter and wider than in any of the other British Upper Silurian species.

This character, taken with the produced and gradually pointed head angles, will enable observers easily to recognize the species. The head also is easily separable at the facial sutures, and this character is worthy of notice.

Locality.—Lower Ludlow Rock, Vinnal Hill, Ludlow.

2. Acidaspis Caractaci, Salter. Pl. VI. figs. 15–17.

A. Caractaci, Salter, Mem. Geol. Surv. Decade 7. p. 7 of text attached to plate 6.

A. semiuncialis, capite semilunari convexo, glabellâ late triangulatâ tuberculatâ, a genis convexis bene distinctâ, utrinque bilobatâ; lobo basali centralem æquante rotundo circumscripto, quam secundo duplo latiore, hoc distinctissimo obovato; superiore obsoleto: [cervice — ?] thorace axi convexo, pleuris ad apices deflexis bispinosis; caudâ 12- (vel 14- ?) dentatâ, spinis primariis fortibus paullum divaricatis, terminalibus minutis 6, externis 2 (vel 3), axi convexo.

The foregoing description of this species, but no figure, is given in the Decade above referred to.

Locality.—It is a common fossil in the fine yellow Caradoc (or Bala) sandstone of Gretton, Shropshire; a locality rich in trilobites and shells.

January 21, 1857.

C. Greaves, Esq., C.E., G. A. Ibbetson, Esq., M.R.C.S., and C. F. A. Courtney, Esq., M.R.C.S., were elected Fellows; and M. E. Lartet was elected a Foreign Member.

The following communications were read:—

1. *On some* Fossiliferous Ironstone *occurring on the* North Downs. By Joseph Prestwich, Esq., F.R.S., F.G.S.

(The publication of this paper is postponed.)

[Abstract.]

Besides a drift of red loam with flints, and the few local outliers of lower tertiary sands and pebble-beds, there are scattered on the summit of the North Downs from Folkestone to Dorking a few masses of sand, gravel, and ironstone, which present a certain regularity of structure and uniformity among themselves, and are clearly different from and of a later age than the outliers of eocene tertiaries on the same hills. Mr. Prestwich had long been acquainted with these ferruginous sands near Vigo Hill, where they are about 20 feet thick; and at Paddlesworth and other places near Folkestone, where they are even better developed; but though the ironstone fragments derived from these beds are frequently found dispersed about the Downs, it was long before he met with any fossils in these beds, with the exception of a piece of fossil wood pierced by *Teredo*, and an obscure cast of a bivalve shell, near Paddlesworth.

In December 1854, however, some blocks of gritty ferruginous sandstone, full of casts of shells, were communicated to the author by Messrs. W. Harris and Rupert Jones, who had met with the specimens in some sandpipes in the Chalk at Lenham, eight miles east of Maidstone, and regarded them as belonging to the Basement Bed of the London Clay. This fossiliferous ironsand on close examination yielded casts of bivalve and univalve shells belonging to nearly thirty genera, besides indications of *Lunulites, Diadema,* &c. The presence of a *Terebratula* very like *T. grandis,* with several species of *Astarte,* and afterwards his finding a large Lutraria-like shell, led Mr. Prestwich to conclude that these sandy beds belonged to the Lower Crag. Mr. Searles Wood, to whom the fossils have been submitted, states that, as far as the evidence goes, he thinks they may be referred to the Upper Tertiaries, and in all probability to the Lower Crag period; the occurrence of a *Pyrula* and an *Emarginula* more especially strengthening this view.

Mr. Prestwich assigns without any doubt this shelly ironstone to the ferruginous sands above referred to, and points to the peculiar concentric arrangement of the contents of the sandpipes of the locality in question as definitely indicating (in accordance with the observations he formerly published in the Society's Journal*) the

* Vol. xi. p. 64.

former existence of horizontal strata of—1. (lowermost) loam with flints,—2. greenish sands with ironstone nodules,—3. yellow and reddish sands,—superposed on the bare chalk, after the eocene beds were for the most part denuded, and before the sandpipes were formed, into which these overlying beds were here and there let down and thereby preserved when further denuding agencies removed the later tertiary beds.

Regarding then the outliers of ferruginous sands and sandstones above referred to as of the age of the Lower Crag, Mr. Prestwich pointed out the relative position of beds of similar structure on the Downs between Calais and Boulogne, and on the top of Cassel Hill near Dunkirk; and of others at Louvain, and at Diest in Belgium, mentioned by M. Dumont and Sir C. Lyell. This extensive range of Crag-beds to the south of the typical Suffolk area, and their considerable elevation above the sea, are of course matters of great interest, not only as pointing out the relative age of some of the drifts, but especially as giving us a still nearer date to limit the denudation of the Weald, and indicating marginal sea-beds now stretching far inland and ranging once probably over the Wealden area,—possibly connected too with the Carentan beds of Normandy.

With regard to the denudation of the Weald, Mr. Prestwich suggests that, the anticlinal axis of the Weald having been somewhat raised during the cretaceous period, and the lower tertiaries partly constructed from its *débris* and gradually distributed over its area, it was again denuded to a further extent in the later tertiary period, some island or islands of the lower cretaceous rocks remaining in its area from which for the most part these sandy ferruginous Crag-beds were derived. The great or final elevation and denudation of the Wealden area was necessarily subsequent to the deposition of these pliocene beds, for their outliers, resting on an old flint-drift, occur on the very edge of the upraised chalk-escarpments of the Weald. This elevation being also subsequent in time to the first or Lower Crag period, Mr. Prestwich suggests, that we have here evidence of the physical cause of the distinction of the two Crag periods. The first Crag sea was open to the south, and of considerable extent; but the last Wealden elevation, cutting off the southern portion, so altered the hydrographical conditions of the period, that a sea open only to the north remained, in which the Red or Upper Crag, with its partially boreal fauna, was then deposited.

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2. *On some* Permian Fossils *from* Durham.

By J. W. Kirkby, Esq.

[Communicated by T. Davidson, Esq., F.G.S.]

[Plate VII.]

This communication comprises a notice of the occurrence of a malacostracous Crustacean and of a new species of *Chiton* in the

Magnesian Limestone of Durham, together with remarks on some other Permian fossils.

1. Prosoponiscus problematicus, Schlotheim, sp.
Pl. VII. figs. 1–7.

Trilobites problematicus, Schlotheim, Petrefact. 1820, p. 41.

Palæocrangon problematica, Schauroth, Zeitschr. deut. geol. Gesell. 1854, vol. vi. p. 560. pl. 22. figs. 2 *a–e*.

In the summer of 1853 I found two imperfect specimens of one of the higher (malacostracan) Crustaceans in the limestone at Humbleton Quarry. At the time I thought that the species belonged to the *Macrura*; but I now find this was an error. A short notice of this interesting discovery appeared in the Address of the President of the Tyneside Naturalists' Field Club, March 15, 1854 *.

At that time I believed that none but the lower forms of Crustaceans had been previously found in the Permian rocks. I have since learned, however, that in Schlotheim's 'Petrefactenkunde,' 1820, p. 41, mention is made of the discovery (in the Zechstein-dolomite of Glücksbrunn) of a peculiar fossil, named by Schlotheim *Trilobites problematicus*, which is probably the same species as mine.

In 1854 Baron Schauroth † authenticated Schlotheim's discovery, and figured and described a specimen of this species as belonging to one of the higher groups of *Crustacea*, naming it *Palæocrangon problematica*. On comparing my specimens with the figures given by Schauroth, I have a little hesitation in regarding them as belonging to the same species; but as "Palæocrangon" does not express the affinities of the fossil animal, I propose, as a more correct generic term, the name *Prosoponiscus* ‡, as suggested by a palæontological friend.

Though my original specimens are in no respect inferior to those of Schauroth's, I did not venture to name and describe them when they were first noticed, but postponed doing so in the expectation of procuring more examples, and obtaining a more definite knowledge of the affinities of the species. It was not, however, until the summer of the present year that any further traces of it were found, when one or two other fragments from a different locality were met with. In all, six specimens have been obtained: two from Humbleton Quarry, three from Field House, Ryhope, and one from Tunstall Hill.

Drawings of the most perfect of these have been submitted to Mr. C. S. Bates, and I am indebted to that gentleman for the following interesting remarks:—

"There is but one Order among recent *Crustacea* with which figs. 1 and 2 can be identified, and that is the *Isopoda*. But the relation of the fossil to the recent species is peculiar. In all recent forms (as far as I know) where the eyes project upon the surface of

* Transactions of the Tyneside Nat. Field Club, vol. ii. p. 333.

† Zeitschrift der deutsch. geolog. Gesell. vol. vi. p. 560. pl. 22. fig. 2.

‡ From πρόσωπον, a face or mask, and ὀνίσκος, oniscus.

the integument the cephalic region is small, being less than the next succeeding segment; but this fact, which is very constant in the adult animals, is not permanent in the larval condition of the same; the head or cephalic segment being more important in relation to the succeeding rings. But from all the larval or adult forms of prominent-eyed *Isopods* this fossil specimen differs in the anterior position of the eye. This may be a specific distinction only.

"The fact that this *Isopod*, found in so early a geological period, assumes rather the larval than the adult form of the recent type, is consonant with all we know of the relation which animals generally of so early a date hold to existing species."

We must therefore, it appears, look upon our fossil Crustacean as belonging to the family *Isopoda*, though somewhat of an abnormal character in reference to the recent forms.

Baron Schauroth's specimen from the Zechstein-dolomite of Pössneck appears to consist of four body-rings and the two posterior segments *. I have been fortunate, however, in procuring one specimen showing the cephalic segment or carapace, with two body-segments attached (Pl. VII. figs. 1, 2, 3).

The carapace is about as long as four of the succeeding body-rings, somewhat less in depth, and slightly compressed laterally; it is carinated along the back and wedge-shaped in front; the eyes are large, round, and prominent, and are placed far forward; from the lower part of each eye runs an indented line, at a short distance from the margin, up to the dorsal region, where it curves forward.

The other five specimens consist of body-rings (2 to 6 in number) and the two great posterior or caudal segments†; and are very similar to the figures given by Schauroth. In one of the Durham specimens (fig. 7) there are six body-rings, and two posterior segments; the others (figs. 4, 5, 6) have likewise the two latter segments, but not so many of the former. The body-segments are narrow, almost uniform in size, but varying a little in depth, the central ones appearing to be the most produced; they overlap each other and the penultimate segment posteriorly; they are slightly compressed, and have traces of a median dorsal ridge; those in front have their extremities turned a little forward, while the posterior ones are bent in the contrary direction. The large penultimate segment is greatly developed laterally; it is strongly carinated dorsally; its ventral margins are slightly convex, as is also the posterior border, which has a deep notch not far from the dorsal ridge; the ridge or keel of this segment is very prominent except anteriorly, where at each side of the dorsal line is a transverse swelling; it is compressed also posteriorly. The next segment, which is the hindermost known, is more compressed than the preceding one, and considerably smaller.

None of the English specimens show the true external surface, nor have any traces of feet or of antennæ been found.

* The latter are regarded as the cephalic and thoracic segments by this author.

† It is probable that we have all the hinder segments in these specimens; but there may possibly be a small terminal one besides.

The specimen with the carapace (figs. 1–3) is one-eighth of an inch long. The largest of those with the body-segments only (fig. 4) is nearly half an inch in length.

2. Chemnitzia Roessleri, Geinitz, sp. Pl. VII. fig. 8.

Loxonema Roessleri, Geinitz, Jahresbericht Wetterauisch. Gesell. 1850–51; Schauroth, Zeitschr. deutsch. geol. Gesell. 1854, vol. vi. p. 538. pl. 21. fig. 9.

In 1853 I obtained a very fine specimen of a ribbed *Chemnitzia* at Humbleton Quarry, which agrees very well with the *Loxonema Roessleri*, Geinitz, as figured by Baron Schauroth in the 'Zeitschrift d. deutsch. geol. Ges.' 1854, vol. vi. p. 538. pl. 21. fig. 9. A notice of the occurrence of this interesting fossil was given, together with that of the above-described Crustacean, in the Transactions of the Tyneside Naturalists' Field Club, vol. ii. p. 333.

The first account of a ribbed *Chemnitzia* from the Permian rocks is found in Mr. Howse's 'Catalogue of Permian Fossils *.' This is probably the same as the one now before us; and is undoubtedly distinct from *Loxonema Swedenborgiana*, King (Monograph Perm. Foss. p. 210), though Baron Schauroth is disposed to consider the two identical. The size, however, is sufficient to distinguish them.

I have given a figure of this specimen (fig. 8), as Schauroth's figure is from a very imperfect individual. My specimen is perfect with the exception of two or three of the apical whorls; the six whorls that remain give a very good idea of the species. This shell is long and slender, tapering gently to an apparently very fine point; the whorls (which, when entire, probably numbered eight or nine) are somewhat convex, rather tumid behind, with the suture deep; they are covered with thick, close-set, transverse ribs, giving to the shell a fluted appearance; the large whorls have about eighteen ribs each, and are finely striated on the under surface. The pillar-lip, as far as can be observed, is straight, but the greater portion of the aperture is hidden in the matrix.

There is little doubt that this is a true *Chemnitzia*: the form of the shell, the character of the whorls with their ribs, the deep suture, and straight columella, pronounce it to belong to this genus. The whole habit of the shell, too, is very similar to that of *Chemnitzia*.

3. Chiton Howseanus, sp. nov. Pl. VII. figs. 9–13.

Three plates of a *Chiton* have occurred at Tunstall Hill, which, on a careful examination, appear to be distinct from *Chiton Loftusianus*, King (Monog. Perm. Foss. p. 202. pl. 16. figs. 9–14), of which I have a full series.

Of the new species two of the plates are intermediate (figs. 10, 11, 12), and one anterior (fig. 13). The former plates are not much compressed; they are wide and obtusely angulated, not much pointed

* Transact. Tyneside Nat. Field Club, vol. i. p. 241.

posteriorly, and they have a surface finely granulated; the lateral areas, which are rather wide, are not strongly marked, and the lines of growth are indistinct; one or two wide grooved lines, commencing at the posterior margin, run parallel to the lower margin, and are continued faintly to the anterior dorsal region. The anterior plate (fig. 13) is marked in a similar manner. The processes for insertion are more prominent, narrower, and not so regularly arched as the apophyses of *C. Loftusianus* (fig. 9).

C. Howseanus may be readily distinguished from the last-named species, which is the only other *Chiton* found in the Permian rocks, by the flatness and greater width of the plates, by the obscurity of the lateral areas, and smoothness (want of strong lines of growth) of the plates. The one or two grooved lines which follow the margin are also characteristic.

I have great pleasure in dedicating this species to Mr. R. Howse, the author of an excellent 'Catalogue of the Fossils of the Permian System of the counties of Northumberland and Durham,' and 'Notes on the Permian System of Durham,' &c.

4. Lima Permiana.

Lima Permiana, King, Monogr. Perm. Foss. p. 154. pl. 13. fig. 4.

It may be interesting to mention that this species, which Professor King founded upon the knowledge of a single valve from Humbleton Quarry, is not of rare occurrence at Tunstall Hill, and at Field House, Ryhope; from which localities I have obtained a very fine series of specimens, completely illustrating and establishing the species*.

This species, in common with all *Limæ*, is characterized by a hinge-area, by its being devoid of a notch under the front ear of the right valve, and by the obliquity of its valves; also by its hinge-area being narrow, its ears small, and its valves smooth, which latter slope gradually and shut close.

5. Hippothoa Voigtiana, King, sp. Pl. VII. figs. 14, 15.

Aulopora Voigtiana, King, Monog. Perm. Foss. p. 31. pl. 3. fig. 13.

Prof. King, in his 'Monograph of Permian Fossils,' gives a short account of this fossil under the generic appellation of *Aulopora*. His description and figures were from casts, no testiferous specimens having been procured at that period, and were necessarily incomplete. As I have been so fortunate as to find a perfect example of this fossil, I have deemed it desirable to give a new figure, and to describe the species afresh.

The cells are oval, widest in front, produced or slender behind; they are placed rather near to each other, the connecting threads being short and thicker than usual; the aperture, which is situated at the distal extremity of the cell, is rather large, circular, and protected by a smooth raised lip.

* In the paper already referred to, Baron Schauroth describes and figures a variety (*subradiata*) of this species.

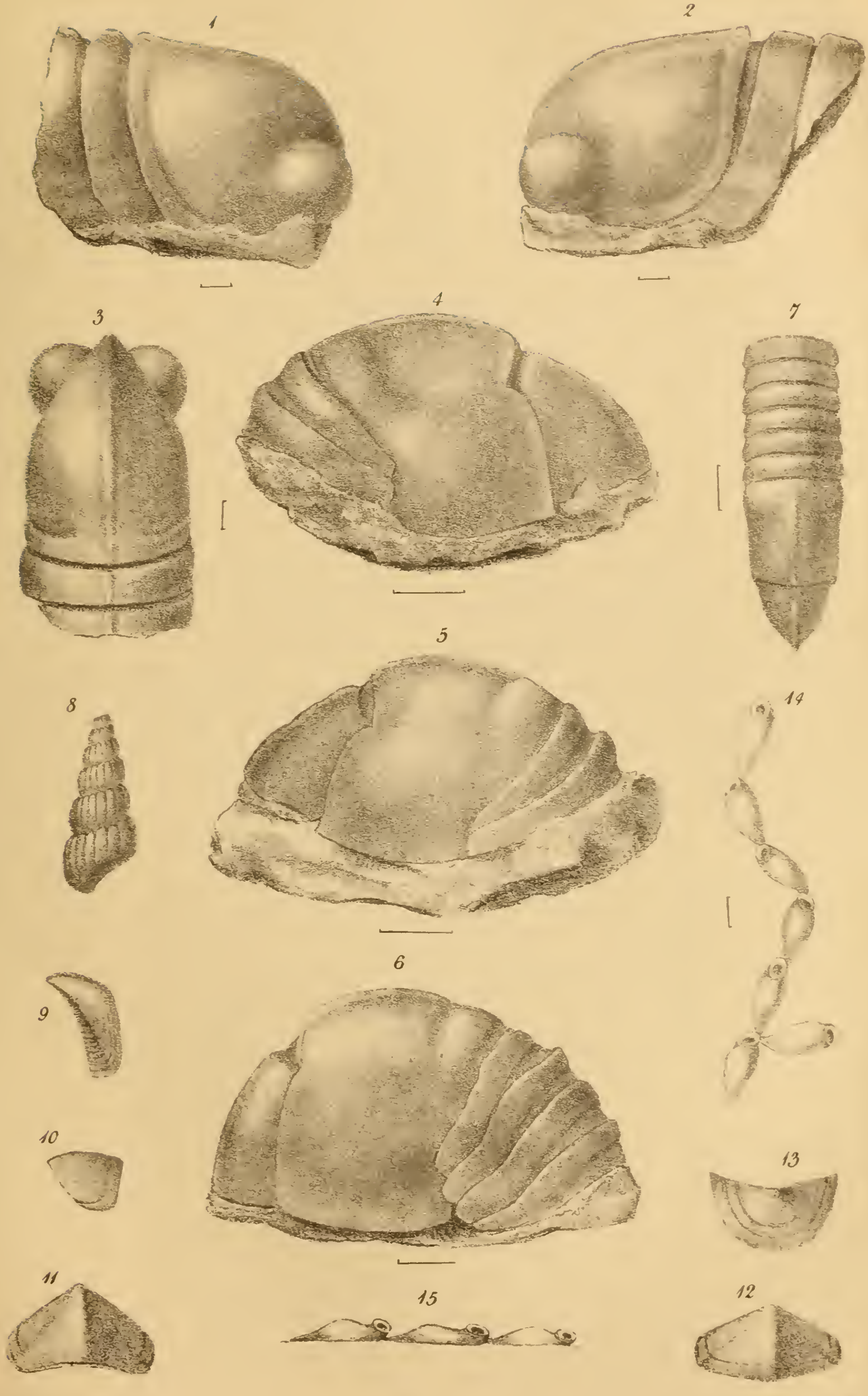
My specimen is not much branched; and the branches always arise from the anterior portion of the cell at an obtuse angle.

This fossil is undoubtedly a *Bryozoon*; and, as the genus *Aulopora* is stated by MM. Edwards and J. Haime to be only the young stoloniferous base of a *Syringopora*, I have, after an attentive examination of its affinities to existing genera, placed it in the species *Hippothoa*, to which it bears a strong resemblance and an evidently close relation.

The specimen figured is from Tunstall Hill, and is attached to the external surface of a *Terebratula elongata*.

EXPLANATION OF PLATE VII.

Figs. 1, 2. *Prosoponiscus problematicus*, Schloth. sp. Lateral views of anterior portion. From Humbleton Hill. Fig. 3. The same. Dorsal view.	Magnified ten times.
Figs. 4, 5. The same. Lateral views of posterior portion. From Humbleton Quarry. Magnified six times.	
Fig. 6. The same. Lateral view of posterior portion. Fig. 7. The same. Dorsal view of posterior portion.	From Field House, Ryhope. Magnified seven times.
Fig. 8. *Chemnitzia Roessleri*, Geinitz, sp. From Humbleton Hill. Magnified four times.	
Fig. 9. *Chiton Loftusianus*, King. Lateral view of an intermediate plate; enlarged. (For comparison with fig. 10.) Fig. 10. *Chiton Howseanus*, Kirkby. Lateral view of an intermediate plate. (Enlarged.) Figs. 11, 12. The same. Intermediate plate. (Enlarged.) Fig. 13. The same. Anterior plate. (Enlarged.) Fig. 14. *Hippothoa Voigtiana*, King, sp. } Magnified sixteen times. Fig. 15. The same. Side-view. }	From Tunstall Hill.



J. W. Kirkby del. G. West lith W West Imp

PERMIAN FOSSILS
from Durham

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I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

AMERICAN Academy of Arts and Sciences, Memoirs. New Series. Vol. v. 1855.
- J. P. Cooke.—On two new crystalline compounds of Zinc and Antimony, and on the cause of the variation of composition observed in their crystals, 337 (plate).
- J. Hall and F. B. Meek.—New cretaceous fossils from Nebraska, with notes on the septa of Baculites, Ammonites, and Scaphites, 379 (8 plates).

American Journal of Science and Art. 2nd Ser. Vol. xxii. No. 66. November 1856. *From Prof. Silliman, For. Mem. G.S.*
- J. D. Dana.—American Geological History, p. 306.
- —— Plan of Development in the Geological History of North America, 335 (map).
- J. W. Mallet.—Lithium, 349.
- W. C. Redfield.—Fossil Fishes of the Newark and Connecticut Sandstone, 357.
- W. J. Taylor.—Meteoric Iron from Mexico, 374.
- W. P. Blake.—On Jules Marcou's Geological Map of the United States and British Provinces, 383.
- E. Emmons.—New Fossil Corals from Carolina, p. 389 (figures).
- E. Hitchcock.—A large striated Boulder in the Drift of Amherst, Mass., 397.
- H. Bessemer.—Manufacture of Iron, 406.
- J. S. Bowerbank.—Origin of Chalk Flints, 415.
- J. W. Salter.—Palæozoic Star-fishes, 415.
- H. Hennessy.—Physical structure of the Earth, 416.
- J. W. Salter.—Pterygotus, Himantopterus, &c., 417.
- R. I. Murchison.—Upper Ludlow Bone-bed, 418.

American Journal of Science and Art. No. 66 (*continued*).
R. Owen.—Stereognathus ooliticus, 419.
—— Dichodon cuspidatus, 420.
A. G. Findlay.—Volcanic Islands S.E. of Japan, 421.
I. Lea.—New Red Sandstone of Pennsylvania, 422.
F. B. Meek and F. V. Hayden.—New Tertiary Shells from Nebraska, and Geology of the Upper Missouri, 423.
A. DeCandolle's Géographie Botanique (noticed), 429.
J. E. Gavit and L. Agassiz.—Gar-pikes, 440.
W. Buckland, Obituary Notice of, 449.
J. D. Dana's Geology of the Pacific (noticed), 452.
J. Leidy's Fossil Fish and Mammalia of the United States (noticed), 453.
M. Tuomey and F. S. Holmes's Fossils of South Carolina (noticed), 453.
C. von Ettinghausen and K. J. Andrae's Fossil Plants (noticed), 453.
H. B. Geinitz's Coal Formation of Saxony (noticed), 454.

American Philosophical Society, Proceedings. Vol. vi. Nos. 53, 54. Jan.–Dec. 1855.
Eckfeldt and Dubois.—Aluminium, 148.
Dubois.—Silver-ore from Lake Superior, 155.

Athenæum Journal for November and December, 1856. *From W. Dilke, Esq., F.G.S.*
Notices of Scientific Meetings.

Basel. Verhandlungen der Naturforschenden Gesellschaft in Basel. Drittes Heft. 1856.
C. Rütimeyer.—Ueber Schweizerische Anthracotherien, 385.
P. Merian.—Astartien bei Seewen und Hobel, 407.
—— Versteinertes Holz im Terrain à Chailles, 408.
—— Versteinerungen aus dem Eisenbahndurchschnitt bei Liestal, 408.
A. Müller.—Ueber die Kupferminen am Obern See im Staate Michigan, 411.
—— Geognostiche Beobachtungen über das mittlere Baselbiet, 438 (plate).

Bent's Monthly Literary Advertiser. No. 632.

Boston Society of Natural History, Proceedings. Vol. v. Nos. 12–21. May 1855–April 1856.
H. D. Rogers.—Footprints and Rainmarks in the Carboniferous Red Sandstone of Pennsylvania, 182.
W. B. Rogers and C. T. Jackson.—Lignites in the Coal-bearing Rocks of Eastern Virginia and Red Sandstone of North Carolina, 186, 189.
J. C. Warren and — Field.—Fossil rainmarks, 187.
C. T. Jackson.—Allanite, 189.
—— On Marcou's Geological Map, 191.
A. A. Hayes.—Chemical characters of the water which enters the sea below Boston, 191.
W. B. Rogers.—Posidonomya from a new locality in Virginia, 201.
—— Influence of trap-rocks on strata in Virginia, 202.

Boston Society of Natural History, Proceedings (*continued*).

C. T. Jackson.—Anthracite-coal from Japan, 207.
J. C. Warren.—Markings on the Connecticut sandstone, 209.
W. B. Rogers.—Clathropteris of the Connecticut Sandstone, 212.
F. Mason.—Laterite, 227.
A. A. Hayes.—Native Iron from Liberia, 230, 250.
J. Wyman.—Bones from the Connecticut Sandstone, 238.
E. Samuels.—Tertiary bed at Cape Cod, 238.
C. T. Jackson.—Geology of New Brunswick and Nova Scotia, 242.
C. T. Jackson and J. L. Hayes.—Nova Scotia iron, 250.
J. Wyman.—Rainmarks and hailmarks on clay, 253, 291.
—— Fossil Foot-tracks in Pennsylvania, 259.
A. A. Hayes.—The serpentine-marble of Vermont, 260.
W. J. Christie.—Mastodon bones at Shell River, 265.
W. B. Rogers.—Rainmarks and the force of raindrops, 267, 282.
J. Wyman, W. B. Rogers and I. Lea.—Footprints and other fossil markings, 276.
J. C. Warren and J. Wyman.—Pterodactyle, 277.
J. A. Dupee and C. T. Jackson.—Native copper from Keweenaw Point, Lake Superior, 279.
W. B. Rogers and A. A. Hayes.—Protocarbonate of Iron in the coal-measures, 283.
J. Wyman.—Slag-like material in the Ohio, 290.
J. C. Warren.—European and American Cheirotheria and new great fossil footprints from Greenfield, 298.
A. A. Hayes.—Coal-beds of Albert mine, New Brunswick, 306.
C. T. Jackson.—On Hitchcock's Gigantipus caudatus, 309.
—— Serpentine-marble of Vermont, 314.
A. A. Hayes.—Saltpetre-earth from Tennessee, 334.
W. B. Rogers.—Petre-dirt of caverns, 334.
C. T. Jackson and W. B. Rogers.—The formation of Stalactites, 335.

Canadian Institute. Canadian Journal. New Series. No. 6. November 1856.

McCosh and Dickie's Typical forms and special ends in Creation, noticed, 528.
Slaty cleavage, 552.
Mean density of the Earth, 552.
Mineralogical Notices, 553, 558.

Civil Engineer and Architect's Journal. No. 272. November 1856.

T. Dobson.—Causes of great inundations, 376.
A. Pope.—Manufacture of iron, copper, tin, and lead, 382.
C. M. T. du Motay and J. J. Fontaine.—Manufacture of iron, 383.

————. No. 273. December 1856.

Conversion of peat into coal, 408.
H. A. W. Ranger and A. Dickens.—Works of the metropolitan water-companies, 409.
F. Coignet.—Artificial stone and cement, 420.
H. Y. D. Scott.—Cement, 421.

Critic for November and December.

Notices of Scientific Meetings, &c.

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Frankfort. Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Vol. ii. Part 1. 1856.
F. Hessenberg.—Mineralogische Notizen, 158 (3 plates).

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Bessemer's Manufacture of Iron, 267, 273, 285.

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J. F. L. Hausmann.—Bemerkungen über die Umänderungen des Glasses, 1.
—— Ueber einige, durch Molekularbewegungen in starren Körpern bewirkte Formveränderungen, welche an metallurgischen Erzeugnissen wahrgenommen werden, 14.
—— Beiträge zur Kenntniss krystallinischer Hüttenproducte, 65.
R. Bunsen und J. F. L. Hausmann.—Ueber das Vorkommen menschlicher Kunstproducte in den Kalktufflagern der Gegend von Göttingen, 96.
F. Meyer.—Versuche über die Cohäsion der Eisendrath-sorte Nro. 12, von 0·144 zoll Calenb. Durchmesser, angestellt auf der Königshütte am Hartz, 111.

Journal of the Indian Archipelago. Vol. i. New Series. No. 1.
J. R. Logan.—The Baniak Islands, 1.
Anon.—Malacca, 43.
T. Oxley.—Banda group (earthquakes), 129.

Linnean Society of London, List of Members, 1856.

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Literarium. Vol. iii. Nos. 14 & 20.

Literary Gazette for November and December.
From L. Reeve, Esq., F.G.S.
Notices of Scientific Meetings.
Ansted's Manual and Page's Text-book, noticed, p. 923.

London, Edinburgh, and Dublin Philosophical Magazine. 4th Series. Vol. 12. No. 80. November 1856.
From R. Taylor, Esq., F.G.S.
Heddle.—Thomson's Davidsonite, 386.
J. W. Mallet.—A zeolitic mineral from the Isle of Skye, 406.

London, Edinburgh, and Dublin Philosophical Magazine. No. 81. December 1856. (*continued.*)
S. Haughton.—Slaty cleavage and distortion of Fossils, 409.
P. J. Martin.—The Anticlinal Line of the London and Hampshire Basins, 447.
R. Owen.—Stereognathus Ooliticus.

Longman's Monthly List of New Books. Jan. 1, 1857.

Manchester Literary and Philosophical Society, Memoirs. 2nd Series. Vol. vi. 1842.
James Heywood.—Coal-district of South Lancashire, 426.

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J. S. Bowerbank.—Fossil wood from the London Clay, 16 (plate).
A. Farre.—Nitella and Wood from the London Clay, 19 (plate).
H. H. White.—Fossil Xanthidia, 77 (plate).
—— A New Fossil Xanthidium, 87.
J. S. Bowerbank.—The structure of the shells of Mollusca, 123 (5 plates).

———. ———. Vol. ii. 1849.
J. B. Reade.—Microzoa of the Chalk, Kimmeridge Clay, &c., 20.
J. Quekett.—Intimate structure of Bone, 46, 59 (4 plates).
H. Deane.—Xanthidia and Polythalamia from the Chalk, 77 (plate).
S. J. Wilkinson.—Xanthidia, Fossil and Recent, 89 (plate).
C. Williamson.—Foraminifera, 159 (3 plates).

———. ———. Vol. iii. 1852.
H. C. Sorby.—Fossil Wood from the Lias, 91 (plate).
W. C. Williamson.—Foraminifera, 105 (2 plates).

———. Quarterly Journal. Vol. i. 1853.
Gold-Dust, Journ., 144.
Pritchard's Infusoria, noticed, Journ., 229.
W. Gregory.—Diatomaceous Earth, I. of Mull, Journ., 242 and Trans. 92.

———. ———. Vol. ii. 1854.
W. Gregory.—Diatomaceous Deposit of Mull, Journ., 24, 90 (plate).
J. Quekett.—Structure of a combustible mineral from Torbane Hill, Trans., 33 (3 plates).
Traill.—The Torbane Hill mineral, Journ., 143.
A. Normandy and W. Gregory.—Boghead Coal, Journ., 200.
W. Gregory.—Fossil Diatomaceæ, Trans., 103.

———. ———. Vol. iii. 1855.
W. Gregory.—Diatomaceous Sand, Journ., 30 (plate).

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J. W. Bailey.—Deep-sea soundings, Atlantic, Journ., 89.
—— Fossil Diatomaceæ, Journ., 92.
H. C. Sorby.—Microscopical structure of Freshwater Marls and Limestones, Journ., 95.
C. B. Rose.—Parasitic Borings in Fossil Fish Scales, Trans., 7.
P. Redfern.—The Torbane Hill mineral and other varieties of Coal, Journ., 106 (3 plates).
Schultze's Foraminifera, noticed, Journ., 143.
J. H. Bennett.—The Torbane Hill mineral and various kinds of coal, Journ., 185.
Presidential Address, and Biographical Notice of Prof. E. Forbes, Trans., 37.

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W. B. Carpenter.—Foraminifera, Journ., 171.
J. G. Jeffreys.—Foraminifera, Journ., 173.
S. Highley.—Micro-mineralogy, Journ., 220.
Micrographic Dictionary, noticed, Journ., 227.
Carpenter's Microscope and its Revelations, noticed, Journ., 231.
W. Gregory.—Diatomaceous Sand, Trans., 35 (plate).
J. B. P. Dennis.—Mammalian Bone from the Bone-bed, Lyme Regis, Journ., 261 (plate).
S. Highley.—Micro-mineralogy, Journ., 271.
J. W. Bailey.—Examination of Diatomaceous Earth, Journ., 302.
—— Deep-sea soundings, Kamtschatka, Journ., 305.

Paris. Annales des Mines. Vol. viii. Part 4. 1855.

Regnault.—Extrait de deux rapports adressés les 15 février et 28 juin 1855 à S. M. l'Empereur, sur les expériences entreprises par son ordre pour déterminer les conditions économiques de la fabrication du gaz à la houille, 1.
Ad. Patera.—Notice sur le traitement des minerais argentifères riches de Joachimsthal en Bohême, 68.
Damour.—Nouvelles recherches sur la composition de l'euklase, espèce minérale, 79.
—— Note sur le péridot titanifère, 90.
Champonnois.—Machine à forer des tuyaux en pierre, 97 (plate).
Description du foyer fumivore de M. Duméry et essais comparatifs avec un foyer ordinaire, 101 (plate).
Fr. de Hauer et Fr. Fœtterle.—Aperçu de la constitution géologique de l'empire d'Autriche. (Extrait du Coup d'œil géologique sur les mines de la monarchie Autrichienne, publié par ordre de l'Institut impérial et royal de géologie, 119.)
Meugy.—Sur le gisement, l'âge et le mode de formation des minerais du département du Nord et de la Belgique, 147 (2 plates).
Delesse.—Notice sur les mines de cuivre du Cap de Bonne-Espérance, 186 (plate).

———. ———. Part 5. 1855.

J. Durocher.—Notes sur l'exploitation des mines et des usines dans le nord de l'Europe (1re partie : Exploitation des mines), 213 (plate).

Paris. Annales des Mines. Vol. viii. Part 5. 1855 (*continued*).
Descloizeaux.—Note sur le diamant noir, 304.
Drouot.—Note sur les amphibolithes de la partie orientale des montagnes du Beaujolais, 307 (plate).
Parran.—Note sur la formation lacustre des environs d'Alais, 328.
J. F. Herland.—Essai sur la géologie de Nossi-Bé (près de la côte O. de Madagascar), 335 (map).
Rapport des inspecteurs des houillères de la Grande-Bretagne (Extrait par M. Herbert, consul général de France à Londres), 365.
Blavier.—Note sur un nouveau compteur mécanique spécialement applicable aux machines d'extraction, 369 (plate).

———. ———. Part 6. 1855.
Bibliographie.
Rapport présenté à S. E. M. le ministre de l'agriculture, du commerce et des travaux publics, par la commission chargée d'examiner le procédé de M. Uchatius, pour la conversion de la fonte en acier fondu, 373.
Descloizeaux.—Notices minéralogiques, 389 (plate).
Haton.—Mémoire sur les établissements d'Agordo (Haute-Vénétie), 407 (plates).
De Sénarmont.—Extraits de minéralogie (travaux de 1854 et 1855), 494 (plate).
Rivot.—Extraits de chimie (travaux de 1855 et 1856), 503.
Meugy.—Résultats de l'analyse de quelques terres végétales au point de vue des amendements dont elles sont susceptibles, 513 (map).

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Sur les progrès de l'industrie des mines au Chili, 543.
Sur la découverte des mines de fer de Cléveland, 544.
Sur l'état de l'industrie du fer dans la contrée de Newcastle, 547.
Sur la découverte d'un gîte de charbon de terre près de l'embouchure du Guadalquivir, 552.
Sur l'organisation de l'école des mines de Freiberg (Saxe), 552.
Note sur la découverte de mines de charbon de terre en Albanie, 558.

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C. Marignac.—Recherches sur les formes crystallines et la composition chimique de divers sels, 1 (plate).
Pissis.—Recherches sur les systèmes de soulèvement de l'Amérique du Sud, 81 (plates).
A. Berard.—Épuration de la houille, 147 (plates).

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J. G. Norwood and H. Pratten.—Carboniferous Fossils from the Western States, 79 (plate).
J. A. Meigs.—Relation of atomic heat to Crystalline form, 105.

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Rand.—Uranite, 286.
F. A. Genth.—Meteoric Iron from Tuczon, Mexico, 317.

Philadephia. Academy of Natural Sciences. Proceedings. Vol. vii. Nos. 8–12 (*continued*).

W. P. Blake.—Tertiary Beds, with Infusoria and Polythalamia, from Monterey, California, 328.

I. Lea.—A new Fossil from the Red Sandstone of Pottsville, 340 (plate).

J. Leidy.—New Fossil Fishes, United States, 395, 414.

T. A. Conrad.—Tertiary Beds of California, and new fossil Bryozoa, 441.

—— New species of Pentamerus.

———. ———. ———. Vol. viii. Nos. 1 & 2.

J. Leidy.—Ichthyodorulites, 11.

—— Extinct Mammalia from Nebraska, 50.

F. B. Meek and F. V. Hayden.—Cretaceous beds and new cretaceous fossils of Nebraska, 63, 70.

J. Leidy and F. V. Hayden.—Extinct Reptiles and Fishes from Nebraska, 72.

B. F. Shumard and L. B. Yandell.—New genus of Devonian Crinoids from near Louisville, 73 (plate).

I. Lea.—New Reptile from the Red Sandstone of Pennsylvania, 77.

F. B. Meek and F. V. Hayden.—New testaceous fossils from Nebraska, 81.

J. Leidy and F. V. Hayden.—Extinct Mammalia from Nebraska, 88.

—— Fossil Seal from the Post-Pliocene deposit of the Ottawa River, 90 (plate).

—— Extinct Mammalia from Nebraska, 91.

J. S. Newberry.—New Carboniferous Fishes from Ohio, 96.

Photographic Society, Journal. Nos. 48, 49.

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J. Girdwood.—Brown lime and rotten-stone, 30.

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R. Hunt.—The present state of Mining Industry (*continued*), 311.

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—— Notiz über den Alpenkalk der Lienzer Gegend, 444.

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W. Haidinger.—Bemerkungen über Herrn Adolph Joseph Pick's "Ansichten über die Sicherheit barometrischer Höhenmessungen," 450.

V. R. von Zepharovich.—Beiträge zur Geologie des Pilsener Kreises in Böhmen, II., 453.

K. Peters.—Bericht über die geologische Aufnahme in Kärnten 1854, 508.

F. von Lidl.—Beiträge zur geognostischen Kenntniss des südwestlichen Böhmen, 580 (plate).

F. Münichsdorfer.—Geologisches Vorkommen am Hüttenberger Erzberge in Kärnten, 619.

M. V. Lipold.—Bemerkungen über Herrn Friedrich Münichsdorfer's Beschreibung des Hüttenberger Erzberges, 643.

K. R. v. Hauer.—Arbeiten in dem chemischen Laboratorium der k. k. geologischen Reichsanstalt, 650.

Verzeichniss der mit Ende September 1855 loco Wien, Prag, Triest und Pesth bestandenen Bergwerks-Producten-Verschleisspreise, 663.

———. ———. ———. No. 4. Oct.–Dec.

W. Haidinger.—Zur Erinnerung an Johann Czjzek, 665.

J. Jokély.—Geognostische Verhältnisse der Gegend von Mirotitz, Chlumetz und Strepsko in Böhmen, 682.

F. R. von Hauer.—Allgemeiner Bericht über die geologischen Arbeiten der Section IV der k. k. geologischen Reichsanstalt in Sommer 1855, 741.

F. Hochstetter.—Geognostische Studien aus dem Böhmerwalde, IV., 749.

F. R. von Hauer.—Das Quecksilbervorkommen von Gagliano bei Cividale in der Provinz Udine, 810.

D. Stur.—Der Gross-Glockner und die Besteigung desselben, 814.

K. Koristka.—Neue Tafeln zur schnellen Berechnung barometrisch gemessener Höhen, 837.

H. Wolf.—Einige barometrische Höhenbestimmungen im Innkreise Ober-Oesterreichs, ausgeführt durch die III. Section der k. k. geologischen Reichsanstalt im Monat Mai 1853, 842.

K. R. von Hauer.—Arbeiten in dem chemischen Laboratorium der k. k. geologischen Reichsanstalt, 850.

Sitzungen der k. k. geologischen Reichsanstalt, 857.

Verzeichniss der mit Ende December 1855 loco Wien, Prag, Triest und Pesth bestandenen Bergwerks-Producten-Verschleisspreise, 922.

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F. Rolle.—Die Braunkohlen-Gebilde bei Rottenmann, Judendorf und St. Oswald und die Schotterablagerungen im Gebiete der oberen Mur in Steiermark, 39.

K. Peters.—Die Umgebung von Deutsch-Bleiberg in Kärnten, 67.

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G. A. Kenngott.—Ueber den Piauzit von Tüffer und den Hartit von Rosenthal in Steiermark, 91.

A. Schefczik.—Ueber das Vorkommen fetter Oele auf der Oberfläche der Flüsse, 95.

V. R. von Zepharovich.—Die Silur-Formation in der Gegend von Klattau, Prestitz und Rozmital in Böhmen, 99.

F. Hochstetter.—Die Höhenverhältnisse des Böhmerwaldes, 135.

K. R. von Hauer.—Arbeiten in dem chemischen Laboratorium der k. k. geologischen Reichsanstalt, 152.

Sitzungen der k. k. geologischen Reichsanstalt, 161.

Verzeichniss der mit Ende December 1855 loco Wien, Prag, Triest und Pesth bestandenen Bergwerks-Producten-Verschleisspreise, 217.

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Fr. Pfaff.—Beurtheilung der Weiss'schen Grund-Gesetze der mechanischen Geologie, 513.

Fr. Sandberger.—Beiträge zur Kenntniss des Mainzer Tertiär-Gebirges, 533.

K. Märtens.—Die Tropfstein-Bildung in der Baumanns- und Biels-Höhle, 537.

Letters: Notices of Books, Minerals, Geology, and Fossils.

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Names of Donors in Italics.

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THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 4, 1857.

Wyville Thomson, LL.D., Professor of Geology, Queen's College, Belfast, and Edwin Lees, Esq., F.L.S., Worcester, were elected Fellows.

The following communications were read:—

1. *On the* Rock-Basins *of* Dartmoor. By John Cleghorn, Esq.

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

I have just seen in the 'Athenæum' (No. 1510) of 4th October 1856 a letter from G. Wareing Ormerod, Esq., F.G.S., headed "Druidical Antiquities," giving the particulars of a "Rock-Basin" discovered by him on Dartmoor. The account given of this basin and the others in its neighbourhood, and the generally received opinions as to their origin, induce me to think they are misunderstood by antiquaries and geologists.

I had my attention called to such basins in 1853 by the paper of Robert Chambers, Esq., of Edinburgh, "On Glacial Phenomena in Scotland and parts of England*," in which he described the celebrated "Giant's Pots" of Sweden. In that paper Mr. Chambers says, "In the midst of a glacialized surface, perhaps on the side of a

* Edinb. New Phil. Journ., April 1853.

mountain, perhaps on the *col*, or summit of a pass through a chain of mountains, we see a circular pit of 3, 6, 10, or more feet in depth, and 3, 6, or even 8 feet in diameter, with sides and bottom worn quite as smooth as the parts of the surface near by;"—and the author imputes their origin to the action of ice. At Wick we have a "Giant's Pot" very like those of Sweden; and, as I was very sure it did not owe its origin to ice, I communicated to Mr. Chambers my views on the subject so far back as June 23, 1853, as follows:—

"In my rambles along our sea-margin, between high- and low-water mark, I observed long ago that stones, when resting on a pivot, or on two points, were kept in constant motion when under the action of the sea, and the effect of this motion was a corresponding hollow on the rock on which they were oscillating and rotating. All here with whom I have talked on the subject are conversant with the fact, and have never had a doubt on the subject.

"To-day I was shown a hole in a rock thus formed, about 5 feet in diameter at the mouth, and 4 feet deep, very smooth, and as circular as if formed by the turner. This pot is on a platform of very hard clay-slate, having on the north a projecting shelf about 10 feet above it; and on the south the rock is 6 or 8 feet higher than the margin of the pot; and there is a narrow entrance sea-ward. There were no stones in the pot when I saw it; but between it and the land there are several that must have been in the pot, for their form and that of the pot corresponded. The interior of the pot is incrusted with balani, limpets, and algæ; but sometimes it is perfectly free from such.

"I half filled the pot with stones of all sizes, from an ounce in weight to that of twenty-eight pounds weight or more, and from the force with which the sea dashed on the overhanging cliff, and then into the pot, the stones must have been kept in perpetual motion, just as sand in a tumbler of water is agitated when an additional quantity of water is poured into the tumbler. The sea was so boisterous when I was there, that I could not ascertain the effect of the stones on the pot or on themselves; but I have no doubt, when I examine it with a calm sea the molluscs and algæ will be found to have been rubbed off, and the stones rounded, if not knocked out of the pot. The Giant's pots or tubs, described at page 37 of the paper, on "Glacial Phenomena," appear exactly to correspond with this pot; and I have no doubt that they were formed by the same agents, and are additional evidence that the sea has receded or that the Swedish coast has risen."

The Dartmoor "Rock-Basins," the "Kettle and Pans" at St. Mary's, Scilly, the "Giant's Pots" of Sweden, and our rock-pots in Caithness have, to my view, the same origin; the process being that I have described, or a modification of it.

I may mention that I frequently visited the pot above alluded to during the summer of 1853, and found that the molluscs and algæ were rubbed off its sides; the stones which I had put in were chafed and rounded; but during the winter that followed, they were all knocked out of the pot. Had I been able to put a large enough stone in it, it appears to me that it would have remained until it had further widened and deepened the pot; and in the process worn itself small, and been in its turn ejected. Such a process repeated, even at long intervals, in geological periods, is sufficient to account for the formation of "Rock-Basins," "Kettle and Pans," "Giant's Pots," and similar phænomena.

The sea round our shores is now receding just as in Sweden, by slow degrees, and has done so, at the same rate, in long past ages. Although Dartmoor be now far from the sea, and the Rock-Basins 1417 feet above the sea-level, yet this surely is nothing against my view of their origin, but tends only to give us an inkling of what is meant by the "long periods" of geology.

The contents of the Rock-Basin, lately discovered on Dartmoor, are such as my views of their origin would have led me to expect, and therefore I conclude it had never been disturbed since it was filled.

[Note.—For notices of Rock-basins, &c., see Geol. Proceed. vol. iii. p. 704; Quart. Journ. Geol. Soc. vol. x. p. 240; Neues Jahrb. 1854, p. 148; Gibbon's Exploration of the Amazon, pp. 283, 291; Mactaggart's Canada, vol. i. p. 77.—Edit.]

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2. *On the* Copper-mines *of* Namaqualand. By Dr. R. N. Rubidge. [*In a Letter to Sir R. I. Murchison, F.G.S.*]

[At the instance of a Mining Company, in 1854, Dr. Rubidge went to Namaqualand to report upon its metal-producing capabilities.

He found that the conditions under which the metalliferous rocks occurred there differed from any which he had previously known or read of, and that they did not take the character of "lodes," as usually understood. On the contrary, he found that all the "runs of ore" in the southern portion of the district visited had the following characters in common, as described in his letter.]

Characters of the "runs" and of the metalliferous axes.—1st. The "runs of ore" presented externally a brown, iron-stained surface, continuous to a greater or less distance; the rock being different from the gneiss on either side of the "run," and has on the under surface stains of silicate of copper (green); small masses of red oxide also were often found on the surface.

2ndly. On closer examination, I found that the dip of the rocks changed in the centre of the "run" to the opposite direction, and then resumed the same direction as the former. Thus at Springbok Fontein the main dip of the country is south. It is changed to a northerly dip on the "run," and the south dip is restored on the northern side, and continues for half a mile, where it changes without the occurrence of metalliferous deposits. This northern dip continues for perhaps twelve miles, and at Windhoek gives place to a southerly dip, of about equal extent, which reaches to within about four miles of Steinkopf, the Missionary Station; these main changes not being marked by any metallic appearance. Indeed, the only peculiarity I have observed in any of them is the presence of rose-quartz in considerable quantities near Steinkopf.

The dip is not, however, continuously north or south in these tracts of country; numerous axes, often coinciding with the strike of the country, or nearly so, but occasionally at angles to it, interrupt the main dip for from 5 to 50 or even 100 paces, and in these axes the metalliferous deposits occur. Springbok and Copperberg are in southerly dip, the latter with a N.W. axis, 6 yards broad, meeting it; Concordia, Kelduner, No. 6 Hooklip, Rietberg, and many others in northern dip; Windhoek and many others in southern dip; and most of these axes concur with the strike of the country. Een Riet and Spectakel are N.W. axes, cutting the main strike; the former at a small angle, the latter at a considerable one. Nabobeeb has a structure which I suspect to be more common than I have had opportunities of observing. The main dip of the country is northerly, and a metalliferous axis occurs which appears to divide into three as it runs up the hill; but I have not made the whole structure out very clearly, never having had more than an hour or two to examine it. About 400 yards to the south-east of this division (a considerable metallic deposit occurs close to the division, which has been worked, and has produced a ton or so of good oxide of copper), a good-sized hill occurs, which presents extensive brown and green stains "indication." The hill is perhaps 600 feet above the level of the spot just mentioned, and may be 300 yards across. Standing on its northern point, near the summit, I found myself on the junction of two axes, the one taking a direction about 60° east of north, the other about 30° west of north, and therefore coinciding with the present magnetic meridian, and also nearly cutting the spot where the threefold division already mentioned occurs. The place has not been worked yet; we can therefore say nothing as to its productiveness. I have said that I believe this meeting of two axes to be more common than I have the means of marking decidedly. I have found it at Copperberg, at No. 12 at Concordia, and, I believe, at Springbok Fontein; but the surface-rock has here undergone so much change, that it is difficult to make out the exact structure.

Previous to writing the above, I had been led to believe that the "run" on which the mine of the Enterprise Company (about twelve miles nearly east of Springbok) was situated was a continuation of the Springbok "run;" but since then I find by examination that the main dip of the country was there northward, and the changed one south. So that, if this be really the continuation of the Springbok "axis of disturbance," it must cross the main axis of change, and cannot be, as I have hitherto regarded it, coincident with the strike of the rocks. The distance is nearly ten miles on the line of strike. Springbok Mine lies about half a mile south of the axis of change, and the Enterprise half a mile north of it. Indeed I begin to doubt whether any of these axes really quite coincide with the strike of the country; but, if they do not, the angle they make is so small as only to be measured by a theodolite.

Rock-structure of the district.—In this part of the country the rocks are chiefly gneiss, with here and there small patches of mica-schist. Some granite occurs; but not, as far as I am able to judge, in the form of dykes; indeed its relation to the gneiss is obscure. Hornblende and actinolite in many varieties occur about the mines, and steatite abounds in some parts. The hypogene rocks are overlaid by clays, shales, and a mass of sandstone, which appears to be continuous with that which caps Table Mountain.

The granite and gneiss.—I cannot perceive that the gneiss undergoes any change in the vicinity of the mines. Specimens 92 and 93 of the collection * sent to illustrate these observations will, I believe, be found to differ from 95 only in having undergone decomposition, which latter is a fair sample of the rock of the country; and these two were taken from within a few yards of each other on either side of the axis of Concordia Mine (Hesther Maria). The centres of the axes are very frequently composed of granite, but this is not always the case; and I do not know that I have seen any mine where granite is not to be found in the works, though the gneiss may meet in well-defined character and with opposite dip over it. In this country I have stood on granite, with gneiss forming the sides of a ravine on either hand, with continuous dip. I have also seen hornblende-schist (felspar and hornblende) passing insensibly, as it were, into syenite and greenstone of perfectly well-marked characters, near Pella. The ravine just noticed is between Pella Missionary Station and a detached station called Klein Pella.

Metalliferous "runs" and axes.—The surface of the metalliferous "runs," whether formed in the centre of granite or not, is much fissured in the direction of the magnetic meridian—nearly, as well as in others; and these fissures, together with the lamination-planes of the gneiss (indicating dip and strike), give the only appearance of regularity to the deposits of ore which they present. The surface, thus cross-fissured, is softened to a considerable degree, and generally presents a dark-brown, iron-stained aspect, which is often visible at a distance of a mile or two. The rocks, in fact, over these axes have undergone great decomposition, and some of their surfaces often present a bright-green stain of silicate of copper. Lumps of oxide, of a rounded form, are often found on the surface; probably half a ton has been picked up on the hill on the declivity of which the works of this mine (Springbok) are carried on. Some fine specimens of the same ore, of a still more compact nature, and containing as much as 60 per cent. of copper, are found in the fissures or on the surface. When these are followed downwards, they often widen at first into good-sized veins, which give promise of a rich return of ore; but when a depth varying from 4 or 5 to 25 feet is reached, they are generally found to contract, and sometimes they terminate abruptly. In either case, they are rarely traced beyond that depth, though occasionally the dip of the rock carries them somewhat further. At a greater depth, purple sulphurets are found; and these

* In the Society's Museum.—Edit.

give way to pyrites, which are contained either in fissures between masses of slightly decomposed felspathic granite (see specimen No. 78), or diffused in grains in the substance of the granite (specimens 83 to 85).

In fact, the formation of all these ores seems to be the result of a process of infiltration, by which the original constituents of the rock are gradually removed, and their place occupied by silicates, oxides, or purple and yellow sulphurets, as the case may be; the silicates and oxides generally occurring on the surface, the sulphurets below*. Masses of oxide of iron in a state to be acted on by the magnet are often found on the surface of these metallic axes. Sulphuret of molybdenum is found accumulated with copper-pyrites at Concordia and at Kildunern; and tungstate of lime, in a lump of about a pound weight, was found enclosed in a mass of red oxide of copper, in Springbok Mine. Manganese, too, has been found in various parts of the country. And near Gams I found green oxide of chrome accumulated in small quantities between the layers of gneiss in an "axis of disturbance"†.

In some few cases the "axes of disturbance" are traceable for but a very short distance. At Nababeeb, for instance, one of the axes is seen on one wall of a ravine, but I could find no trace of it on the opposite side; the gneiss, however, there assumes so granite-like an appearance, that the dip and strike are scarcely distinguishable; and this is often the case in this country. Indeed I find it a matter of great practical difficulty often, to say whether a rock is granite or gneiss; therefore I call these rocks "gneiss-like granite" or "granite-like gneiss," according to their appearance.

Hypothesis of origin of the metalliferous condition of the rocks.—As to the nature of the process by which the deposition of metal in these axes has taken place, I must leave the solution of the question to abler and more experienced heads than mine. I can only offer

* The formation of a vein of the sulphuret may be illustrated by specimen No. 80; the gradual infiltration of small masses of the same material, by specimens 79, 82–85, and the completion of the process by the removal of the granite entirely, and its displacement by pyrites. (See specimens 86 and 81.) Other specimens will illustrate the same process with the oxides and silicates, where the felspar will in some be seen just tinged with the contact of the mineral, but only slightly, if at all decomposed. Next, the felspar has lost its hardness, but still retains its crystalline form. Again, the constituents of the original rock have almost disappeared, but the change is known by the felspathic portion now decomposed into clay, coloured by oxide or silicate, adhering to the tongue. Nos. 51, 57, and 88–91 will, I think, show these changes.

† Perhaps I ought to apologize for the use of this expression; but I apply it to those axes which do not permanently change the dip of the gneiss, in contradistinction to the three I have mentioned above, on either side of which the dip continues nearly the same for miles. These last I would call "axes of change." Some of the former kind of axes present very little metallic appearance in parts of their course, but, I think, are traced for a great distance (which they often may be, from the two sides formed by the almost vertical rock being infiltrated by quartz, which renders them conspicuous). Most of them will be found to contain iron, copper, or chrome in some parts. A mine was worked in one place in a green stain of chrome which was mistaken for copper.

such facts and suggestions as an extensive journey among these deposits, and those of a different class (in the northern district) which I shall presently describe, has presented to me,—premising that in this part of the country, as far as my observation goes, it is *only in the axes of disturbance* that deposits of metal have taken place. A spot of granite, about the size of my hand, surrounded by silicate of copper in quartz, on the road to Kôk Fontein, is the only exception I am acquainted with; and even here the change of country may be said to have commenced, though one metallic axis at least does occur beyond it.

That the deposit of metals is in some way connected with the passage of water through the rocks is shown by several facts. 1st. At Van-der-Stell Mine, which is a shaft sunk by a Governor of the Cape (of that name) in 1680, a deposit of dendriform silica coloured with silicate of copper lines the inner wall of the shaft (see specimen 97). 2ndly. My friend Dr. Atherstone found the jaw of a Dasje (*Hyrax Capensis*) stained green with silicate of copper; and at Spectakel Mine a frog was found, in a dried state, coloured by the same mineral. The waters of this country are generally brack, containing chloride of sodium in considerable quantities (all the felspar is soda-felspar). Then the decomposition of the felspar, its colouring by oxides and silicates, and its conversion into clay, are, I think, evidently the results of water-action. As to the question, which of the mineral constituents of the rocks first gives way, I hope the specimens herewith sent for illustration will put geologists at home in as good a position for judgment as myself. The water seems to me sometimes to penetrate between the layers of mica, conveying with it the copper; and, from the position so taken up, to have attacked the felspar in some cases; but in others the felspar seems to have undergone considerable change while the mica is intact. Again, the quartz appears to be the first to suffer in some instances, and to be the last in others.

Relative elevation of mines.—The different degrees of elevation of the several deposits of ore do not appear to me to exert any marked influence on them. At Springbok the mine is about 3000 feet above the sea, and, perhaps, 600 above the adjacent plain; at Concordia the elevation is about the same, but the "run" is on a plain, and in a hill of slight elevation. At Henkries it is on a plain, and these are all productive places.

At Rietberg the run is near the summit of a mountain 4500 feet high; at Spectakel the elevation is, I think, 800 feet above the sea-level, at the foot of a high hill.

Other agencies besides water.—What effect terrestrial thermo-electricity and its consequent magnetic phænomena may have on these deposits, I know not. These metalliferous rocks generally run nearly in an east and west direction, that is with the strike of the country; but Spectakel is, I believe, a N.W. "run," though there is some obscurity about it. I should not wonder if it turns out, like Nababeeb, to be a meeting of two axes. I found the walls of two of the cuttings on the Concordia property affect the magnetic needle. At the spot where the experiments were tried, the rock was granite or gneiss, with very little appearance of iron; but still a detached piece of it at one spot affected the needle. I will further examine this point *.

The yield of the mines.—As to the prognosis of these mines, I cannot at present regard it as favourable. This mine (Springbok) continues, at the greatest depth yet worked, to yield abundant nests and small veins of good oxide and sulphurets; but the depth does not exceed 40 feet at the most.

At Concordia the proportion of stone to the pyrites is very great at the same depth; and the rock seems likely to be a hard non-metallic felspathic granite at a few fathoms deeper.

At Schaap River Mine, about four miles E. of Spectakel, a level, driven through the base of the hill at right angles to the course of the ore, cuts through hard and unstained granite-rock. Indeed, from the evident connexion of these deposits with the action of water, and the slight depth to which the hardness of the rock enables us to penetrate, I think it would be unreasonable to look for rich deposits at any great depth.

Northern district.—Very different from those which I have described are the deposits of ore in the vicinity of Henkries, and thence ascending the Orange River to Pella. The rocks of this part of the country are principally mica-schist, hornblendic schist, and chloritic and felspathic rocks, with occasional large beds of gneiss. These are penetrated by granite-dykes in every direction; many taking the line of strike, others cutting the strata at all angles. I cannot help thinking that the close study of the rocks of this country will greatly modify the opinions of geologists as to the relation between granite and gneiss and other metamorphic rocks. I have seen a granite-vein of a serpentine form, not 1½ inch wide, and less than 2 feet in length; the gneiss through which it passed was not at all disturbed. Again, I have seen in gneiss apparently isolated masses of granite, from the size of one's hand to that of a mass of many tons weight. Many such things as these seem to me to throw doubt on the question, whether granite always penetrated the strata from below.

Occurrence of ore in the northern district.—I have said that the Orange River country is composed of hornblendic, micaceous, and other rocks, and is penetrated by granitic dykes and masses. Oxides, sulphurets, silicates, and carbonates of copper occur in small masses, disseminated through the crystalline veins; and sometimes in the rocks or their margins. The veins which contain the most

* Since I finished this letter, I have made experiments on the magnetic phænomena of Springbok Mine, and I have satisfied myself that there was a considerable effect exerted on the needle. Indeed it was nearly deflected to an angle of 90° from its proper direction in a recent cutting in the drift-work of the upper part of the mine. Mr. Green assisted me in these experiments, which I endeavoured to free as much as possible from all source of error by trying parts of the wall, detached, on the needle. It was not affected by either the rock or the ores of the wall.

ore are generally, I think, those which are interposed between layers of felspathic rock, with more or less of hornblende, and its varieties. They are composed chiefly of quartz, but felspar and mica may generally be found. The copper appears to be chiefly superficial, as the removal of a few feet of the rock usually suffices to get rid of all stain. These masses of crystalline rock are often spindle-shaped, interposed between the strata; capable of being entirely removed by digging a few feet deep, yet often bending the strata on either side. In veins thus formed, and in masses of quartz, I have found, besides the infinite varieties of hornblende and actinolite, the following minerals: schorl, octohedral iron-ore, garnets, a white mineral very soft, but fusing with bubbling, resembling tremolite, but harder, and phosphate of lime in hexagonal prisms, 4 inches long: the last I thought an interesting discovery; I believe that some crystals of much smaller size have been found at Bonte Koe.

The overlying quartzite and other beds.—Resting on these metamorphic rocks are a series of beds, the lowest of which are of a hard quartzose nature; indeed the silica infiltrating the gneiss, and supplying the place of the felspar and mica removed, often gives the beds the appearance of quartzite, conformable with the metamorphic rocks. I was convinced that this was the case at Springbok; but, when I saw the whole side of a mountain, as T'Quaib, formed of this quartzite-rock, I hesitated in assigning to it this origin. Subsequent observation, however, has quite convinced me that I was right.

The upper beds are much softer; some of them are composed of clay, and contain *fossil vegetable impressions.* A more hard and compact sandstone presents a well-defined *ripple-mark.* These beds are generally horizontally disposed, and appear to have undergone but little change since their deposition; though some, which rest against the hills near Byzonder Meed, seem, however, to take an inclination from the position in which they were deposited. But I hope to make a collection of fossils from these, and to write another letter about them.

[Note.—Observations of the Copper-districts of Namaqualand will be found in the 'Reports of the Surveyor-General, Charles D. Bell, Esq., on the Copper-fields of Little Namaqualand, &c.,' Cape Town, 1855. M. Delesse's 'Notice sur les Mines de Cuivre du Cap de Bonne-Espérance,' Annales des Mines, 1855, vol. viii. p. 186; the 'Provisional Report upon the Nature and General Character of the Copper Districts of South Namaqualand, by A. Wyley, Esq., Geol.-Surveyor to the Colony of the Cape of Good Hope,' Cape Town, 1856.—Edit.]

February 20, 1857.

ANNUAL GENERAL MEETING.

[For Reports and Address see the beginning of this volume.]

February 25, 1857.

John Calvert, Esq., C.E., Rosbrin Castle, Co. Cork, was elected a Fellow.

The following communications were read:—

1. *Notice of the late* Earthquake *at* Crete. By H. S. Ongley, Esq., H.M. Consul in Crete.

[Forwarded from the Foreign Office, by order of Lord Clarendon.]

This notice was communicated in three despatches relating to the occurrence of the earthquake in Crete, in October 1856, which was accompanied with much destruction of property and loss of life at Canea, Retimo, and the neighbouring villages.

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2. *On some* Remarkable Mineral Veins. By Professor D. T. Ansted, M.A., F.R.S., F.G.S.

In a previous memoir (Quarterly Geological Journal, vol. xii. p. 144), I have described the conditions of the great copper lode of Cobre in the island of Cuba. I have now to offer remarks on three lodes, or rather groups of lodes; one in the central part of the same island (Cuba), and the others situated in the United States of North America.

1. *On the San Fernando Copper Lodes, near Cienfuegos in Cuba.*

The central part of the island of Cuba is not unknown as a mineral district, although up to the present time no great development of any lodes has been recorded.

This district may be described, geologically, as consisting of granites and syenites (passing into other crystalline rocks of a porphyritic nature), partly covered with a brecciated and highly calcareous conglomerate. The crystalline rocks form the mountain-chain of Trinidad on the south coast of Cuba, and occupy a valley beyond this range towards the north, where the bed of a river lays bare a fine surface of syenite, crossed by systems of veins of felspar, spotted occasionally with silver-ore *.

Beyond this valley towards the north is the range of hills containing the San Fernando lodes. The hills are of moderate elevation (not generally reaching 1000 feet above the sea), somewhat scarped towards the south, and having moderate slopes towards the north. They are composed of a rock not unlike that described in my previous memoir on the Cobre mines, and widely distributed in some form or other throughout Cuba. Here also, as elsewhere, the passage from a true porphyry into a calcareous conglomerate of angular stones, is

* I observed in one place a striking instance of the intersections and heaving of a vein of felspar, and some cross-veins laid bare on the bed of a river for an area of several acres. I have not seen a more perfect example of its kind in any part of the world.

in many places so gradual as to render it almost impossible to draw the line between them. The large per-centage of calcareous matter is very characteristic, and the rock often decomposes into a rich and valuable soil.

Still further to the north the conglomerate character is better defined; and at a distance both towards the north and west a compact limestone appears to overlie it. The general range of the rocks and lodes may be stated as approximately east and west with a northerly dip. There are, however, local exceptions.

In the mineral field, as at present known, there are two principal groups of lodes, of which the northern has been most examined. Both are in the same kind of rock, and they are parallel to each other, and at no great distance apart. They are very easily recognized at the surface by a strong outcrop of quartz and oxide of iron, the latter often colouring the former of a bright vermilion tint. The quartz is often spongy and cellular, but sometimes compact. The width varies, occasionally reaching fifty feet; and, although obscured by a rich tropical vegetation, there is no difficulty in tracing one of the lodes for upwards of a mile continuously, and at intervals towards the east for a further distance. The total breadth of mineralized ground occupied by the two groups of lodes is about 1200 yards.

There are two well-marked lodes in the northern, and three in the southern group, and all appear to be cut off towards the west by a change of ground on the other side of a gorge, along which runs the stream called the Arroyo de la Bermeja.

The lodes are all nearly vertical; but, while the two northernmost dip a little towards the north, the others seem to underlie south. The northern lode is that on which mining operations have been chiefly carried on, and here ten pits were sunk at intervals along a distance of about 800 yards. Most of these pits went down at once at very shallow depths into deposits of rich decomposed ores of copper, through gossan consisting of iron-oxide and quartz, with occasionally a good deal of blende. The ores included blue carbonates of copper, red and black oxides and purple and yellow sulphurets *, besides decomposed carbonates, oxides, and sulphurets. Of these ores, not less than ten thousand tons were extracted and exported from Cienfuegos. It may safely be assumed that these could not have averaged less than 15 per cent., and they were probably much richer. The deepest pit was 32 fathoms, but the principal workings are very much shallower than this †.

At the time of my visit the lode exposed in the bottom at one point was 35 feet wide, including about 5 feet of "horse" or barren ground. The hanging-wall was soft and loaded with mundic, which penetrated

* The sulphurets seen were for the most part pale-coloured and hard, and looked poor. A sample of this kind, however, yielded on analysis 17·80 per cent. of copper and 7 ounces of silver to the ton of ore.

† From a statement made by the late owner of the mine, I learn, that during the year ending 1st July, 1856, and therefore since my visit, about 480 tons of ore, averaging 17 per cent., were shipped for Swansea; and about 300 tons, supposed to be at least equally good, were sold to the United States, the total value being £12,000. During that time the average number of hands is stated to be ten men.

and impoverished the upper side of the lode. Nearer the foot-wall, the ore consisted of rich yellow sulphuret of great purity. The country and horse of ground were of the usual conglomerate, but of very crystalline nature.

The other lode of the northern group has also been sunk upon, and ore was found under similar conditions. The lodes of the southern group are similar in outcrop, but the operations hitherto carried on are too inconsiderable to justify any conclusions.

The San Fernando lodes possess considerable interest in reference to scientific mining. Their dimensions and the nature of their outcrop, the associated minerals, the calcareous nature of the enclosing country, the existence of horses of barren country within the lodes, and the extraordinary richness of the bunches of ore near the surface, are all phænomena worthy of notice, not only in themselves, but when considered by the side of the great mineral deposit of Cobre in so many respects analogous. The distance from Cobre (as much as 350 miles) does not lessen the interest thus excited, as the relations are much more geological than topographical. As there undoubtedly exist other copper-districts in the island still further west, not hitherto worked, and only known by their rich outcrops under somewhat similar circumstances, the island of Cuba, already remarkable for its mineral wealth, may be expected to preserve for some time to come its extraordinary reputation in this respect.

The distance of the San Fernando mining-district from the harbour and town of Cienfuegos is about twenty-eight English miles, and a line of railway from the town to Villa Clara crosses the country about fourteen miles to the north.

2. *On some Copper Lodes near Sykesville, in Maryland.*

The eastern flanks of the great mountain-chain of eastern North America, and the comparatively low ground near the mountains towards the east, are remarkable as exhibiting in abundance metamorphic, and even igneous, rocks in belts highly inclined and of the most varied character, while the chief axis of the mountain-chain often consists of stratified fossiliferous rocks but little altered. Amongst the metamorphic belts numerous metalliferous veins have been already discovered and partially worked in Pennsylvania, Maryland, Virginia, and North Carolina, and as they possess certain peculiarities in common, an account of the most characteristic of them will not be without value.

In the winter of 1854 I had occasion to visit some mines not far from the Sykesville station on the Baltimore and Ohio railroad, about twelve miles east of the Blue Ridge, and thirty-two miles west of the city of Baltimore.

The country here consists of metamorphosed rocks ranging N.N.E. and S.S.W., parallel to the mountain-chain, and dipping at a high angle to the E.S.E. The rocks include syenite, a band of limestone, and a mass of steatite, all seen before reaching Sykesville from the west. In the immediate neighbourhood they include decomposing granitic and syenitic gneiss, mica-schist, hard schists alternating with talcose and chloritic bands and steatite, and micaceous slate. In the hard schist with magnesian rocks are occasional bands of hard grit-stone, and here also occur the mineral veins, the outcrop of which is parallel to the stratification, and which not unfrequently project above the general level of the country, owing either to the hardness of the veinstone being greater than that of the enclosing rocks, or to the latter decomposing more readily than the former.

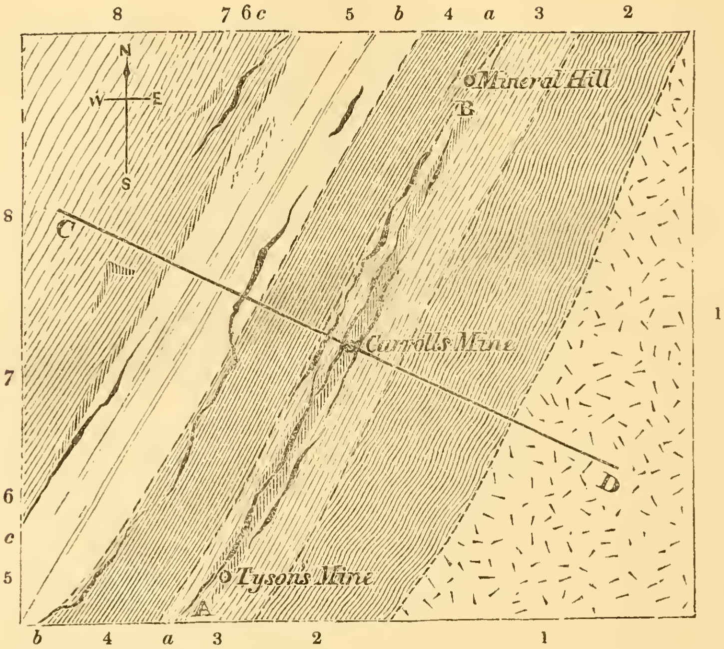
The diagram, fig. 1, p. 244, is an eye-sketch of the surface, showing the relative position of the lodes and the various rocks. The veins are nearly vertical; but the one best known (*a a*) appears to dip slightly to the W. or W.N.W., as indicated in the transverse section, fig. 2.

This vein, which is of some importance, and which may here be called the *Springfield lode*, crops out as a projecting ridge several feet wide, composed of hard ferruginous quartz, with very numerous disseminated crystals of magnetic iron-ore. At Mr. Tyson's mine (see plan, fig. 1), a string of this ore was found, varying in thickness from 10 inches to as much as 10 feet, going down towards the south in a kind of irregular pipe, always on the course of the lode, as shown in the diagram, fig. 3. A shaft being put down about 10 fathoms, considerable supplies of iron-ore of excellent quality were raised, consisting of protoxide and peroxide of iron in crystals. On continuing the shaft downwards a change took place; the course of ore and the condition of the veinstone presented an altered character, and the fine pure and crystalline oxide of iron became spotted and mixed with iron-pyrites, while horses of dead ground split the vein and altered its character. On the upper side of these horses also, considerable deposits of copper-pyrites were found, and I saw about 80 tons of such ore on the dressing-floor of Mr. Tyson's mine, estimated to yield 14 to 18 per cent. The depth of the shaft at the date of my visit was 50 fathoms, and no troublesome quantity of water had been met with. In the bottoms the lode was described as consisting of a good course of copper-pyrites on the foot-wall, associated with magnetic iron-ore, some silicate and carbonate of copper, and some mundic; the copper-pyrites being readily separable by hand-picking. The lode had not become settled, and the ore still occurred chiefly on the fork of the horses of dead ground, and in a comparatively narrow belt going down south on the vein.

The same band of quartzose rock in schist that contains the course or pipe of ore worked in the Springfield mine is again seen at the surface, and has been sunk upon in an adjoining property to the north. Two other similar bands parallel to it and at a distance of only a few fathoms are characterized by the same peculiar kind of gossan, and others have been observed between this tract of country and the mountains of the Blue Ridge. In all these cases the outcropping veins are harder and less decomposed than the intervening country, while parallel quartz-ledges alternating with bands of talcose schist are common.

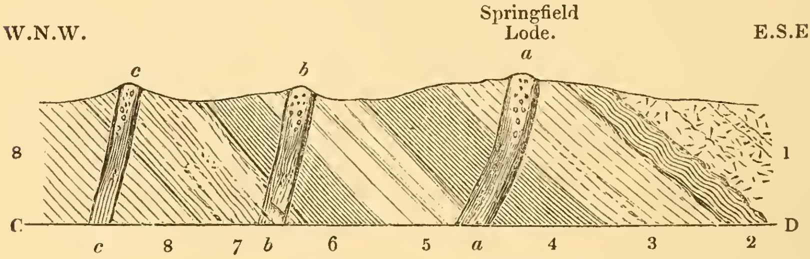
At Carrol Mine, about two miles north of the Springfield Mine above described, mining operations have been carried on to some extent on what is probably a continuation of the same lode. Shafts

Fig. 1.—*Plan of the Country near Sykesville.* (About four miles square.)



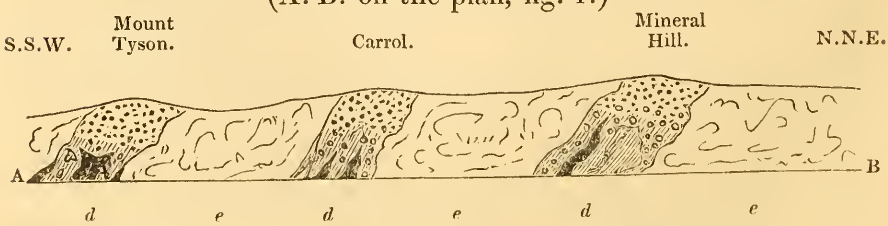
a a, *b b*, *c c*, The three parallel lodes.
A. B. Line of section (fig. 3) on the course of the Springfield lode (*a*).
C. D. Line of section (fig. 2) across the three lodes *a*, *b*, *c*.

Fig. 2.—*Transverse Section across the Lodes in the Sykesville District.* (C. D. on the plan, fig. 1.)



1. Syenite.
2. Granitic gneiss.
3. Hard micaceous schist.
4. Steatitic schist.
5. Mica-slate.
6. Schist with steatite.
7. Mica-slate.
8. Schists.

Fig. 3.—*Section on the Course of the Springfield Lode.* (A. B. on the plan, fig. 1.)



d d. Courses or pipes of ore in the lode. *e e.* Barren veinstone.

have here been sunk, one to 12 and another to 25 fathoms, and adits driven in from the hill-side to cut the lode at convenient places. From an adit-level driven into the hill about 35 fathoms, blocks of hard compact steatite, deeply tinged with copper-stains, and portions of the lode with good stones of copper-ore, have been brought. Excellent stones of ore have also been taken from the shafts, and the indications of a good copper-lode were very strong.

Two miles still further to the north, at a place called "Mineral Hill," a course of ore is indicated under precisely similar conditions, and some simple surface-operations have been commenced which show that the copper-pyrites is here nearer the surface than either at Springfield or Carrol. At Fenceburg, six miles beyond, and always in the same direction, copper-ore has been obtained to profit under similar circumstances.

It appears, therefore, that in this district there are several pipe-like courses of copper-ore occurring in veins parallel to the stratification, proved for a length of at least ten miles and at least three in number; that the courses of ore are individually of no great magnitude near the surface; that they are surmounted by a gossan of crystalline protoxide and peroxide of iron in a highly magnetic state; that the ore-deposits underlie to the south within the vein; that the enclosing rock is highly mineralized; that steatitic rocks and talcose schists prevail near the orey parts of the veins; and that the veinstone in the intervals between the orey portions contains little or no magnetic ore.

Near a remarkable and exceedingly picturesque spot called the Point of Rocks, where the Potomac River emerges from a narrow gorge on coming out from the Blue Ridge, an enormous mass of *limonite* or hydrous oxide of iron crops out and has been quarried to a considerable extent. This ore occurs in a soft slaty rock dipping east, and appears to be the gossany top belonging to several lodes, between each adjacent two of which a soft blue shale intervenes. The masses of ore occur in the form of geodes or concretions, with a cavity in the interior often partially filled with clayey matter. These geodes are from 20 to 100 feet in length, and are sometimes round, but more frequently much flattened. A partial attempt has been made to cut across the ferruginous mass, but the width was unproved at the time of my visit. The mass appears to extend for some distance parallel to the Blue Ridge, but the ground is covered up.

There is no proof of copper existing beneath this mass of iron-oxide, but it has every appearance of being the top of a lode which may probably be cupriferous. It is evidently the gossan of an important group, as blocks of quartz and masses of veinstone are distinctly traceable along the line of the crop to some distance.

3. *On the Copper Lodes of Ducktown in East Tennessee.*

In the eastern corner of the State of Tennessee, near the point where that State meets North Carolina and Georgia, and not far from Virginia, is a small depressed mountain-tract in the Central Alleghanies, crossed nearly at right angles by the Ocooee river*. This district and the corresponding rocks in the State of Virginia, about 100 miles to the north, are remarkable for the presence of several large lodes, all indicated by a strongly marked gossan, underneath which has been found a quantity of rich copper-ore of peculiar quality. These lodes have attracted great attention in America, and the ore lying under the gossan has been rather extensively worked in four mines, and partly opened in others, but hitherto without much profit, owing to the enormous cost of conveyance from the mines to a market. Notices of the mines will be found in Whitney's 'Metallic Wealth of the United States,' and reports on the district have been published by some American geologists ; but little attention has been paid to what seems to me a most essential feature, and I propose here to describe the lodes and the mineral field from notes made during a careful investigation in the winter of 1854–1855.

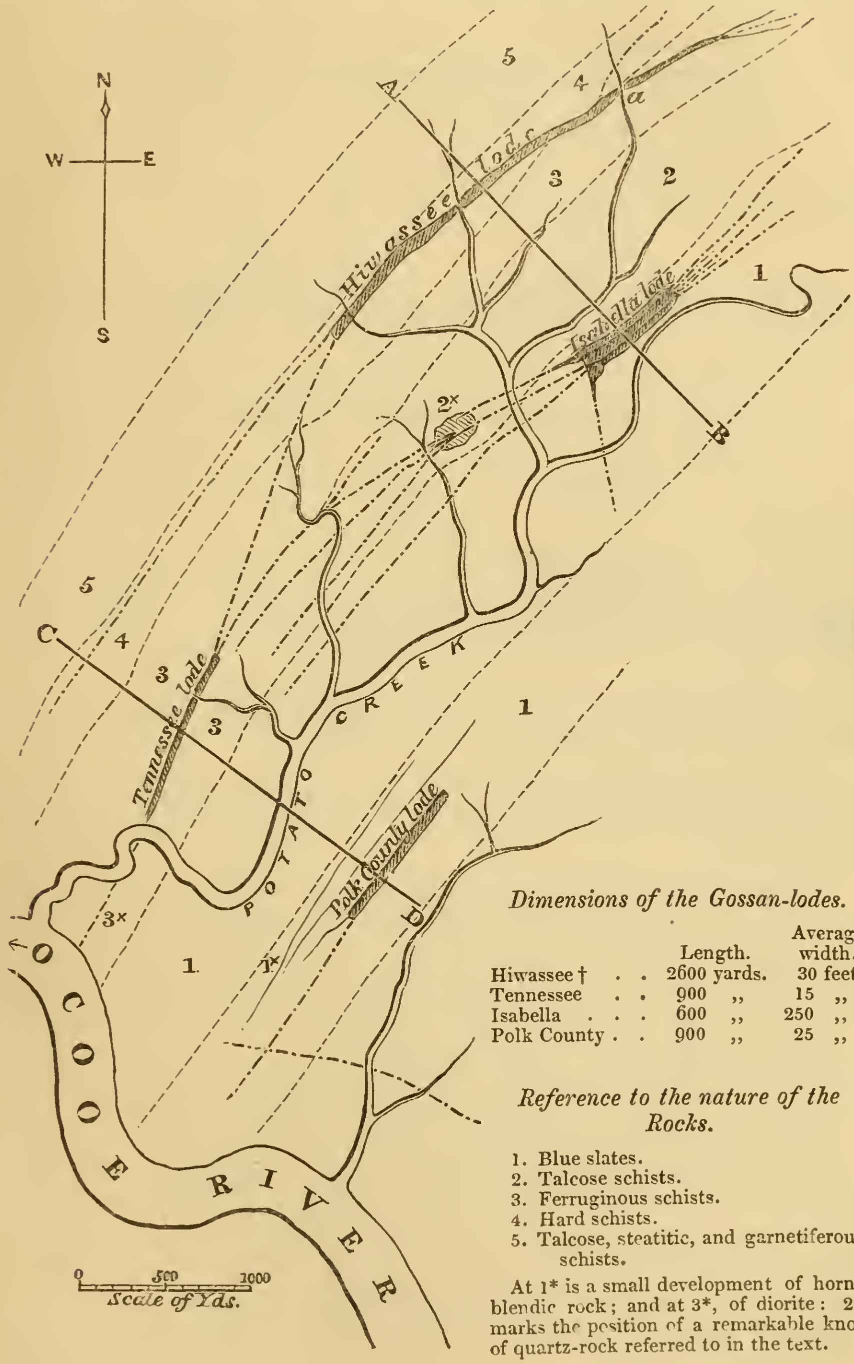
The country consists of altered talcose and chloritic schists, probably of Silurian date, alternating with hard micaceous grits and with other rocks distinctly crystalline and of a porphyritic character. All these have the same general strike as the mountain-range, which bears N. 30° E. by S. 30° W., and all show a great uniformity in the direction and amount of their dip, which may be described as uniformly S.E. at a high pitch. The talcose schists occasionally pass into garnet-schists, and sometimes become steatitic.

The schists and other rocks are traversed by, or alternate with, numerous bands, veins, or strings of quartz, hard and crystalline, irregular in extension and thickness, but on the whole corresponding in bearing with the schists. These quartz-strings are neither regularly stratified with the other metamorphic rocks, nor do they cross the stratified rocks after the manner of true metalliferous veins. They rather suggest a different origin, reminding one of the segregated strings of calc-spar in certain lime-rocks, or of strings of sulphate of baryta and gypsum in clays. In the Ducktown district, as indicated in the map (diagram, fig. 4), they occasionally diverge from or converge towards each other; they unite in one place to form a large quartz-knot, and they are sometimes seen crossing the schists nearly at right angles to the direction of their strike.

The width of these veins varies from a few inches to 10 or 15 feet; and either at or near the surface the quartz often has a strong ferruginous stain, or contains, disseminated through it, a quantity of iron-oxide, forming a gossan, as already alluded to in the case of the cupriferous lodes. The iron-oxide is generally a brown hæmatite; but magnetic iron-ore is not unfrequent, and in the spot marked on the map as a quartz-knot, I observed the compass to be strongly affected, although there was no surface-indication whatever of a lode. Stains of iron-oxide are not uncommon in the schists, even at some distance from the quartz-outcrops, so that the soil is in many places either of a deep ochraceous yellow, dark reddish-brown, or vermilion tint, from the large quantity of decomposed iron-oxide close to

* This river afterwards runs through a narrow gorge in the mountains, and ultimately enters the Hiwassee, an important tributary to the Ohio.

Fig. 4.—Map of the Ducktown Mineral District, Tennessee, U.S., showing the principal Gossan-lodes and Quartz-veins.



Dimensions of the Gossan-lodes.

	Length.	Average width.
Hiwassee † . .	2600 yards.	30 feet.
Tennessee . .	900 ,,	15 ,,
Isabella . . .	600 ,,	250 ,,
Polk County . .	900 ,,	25 ,,

Reference to the nature of the Rocks.

1. Blue slates.
2. Talcose schists.
3. Ferruginous schists.
4. Hard schists.
5. Talcose, steatitic, and garnetiferous schists.

At 1* is a small development of hornblendic rock; and at 3*, of diorite: 2* marks the position of a remarkable kno of quartz-rock referred to in the text.

-.-.-.-.-. Quartz-veins.

- - - - - - - Approximate boundaries of the different schists.

The gossan-lodes are indicated by shaded lines.
A B and C D, lines of sections, figs. 5 and 6, p. 248.

† The main portion of the Hiwassee lode having the average width above stated does not extend for more than 1600 yards. There are, however, proofs of its extension beyond the point marked *a*, though with a much less width.

the surface. There are also cases in which the blocks of quartz, forming the outcrops of large veins, are replaced or accompanied by

Figs. 5 & 6.—*Sections across the Metamorphic Rocks, showing the Gossan-lodes in the Ducktown Mineral District.*

Fig. 5.—*Section from* A *to* B *on the Map, fig.* 4.

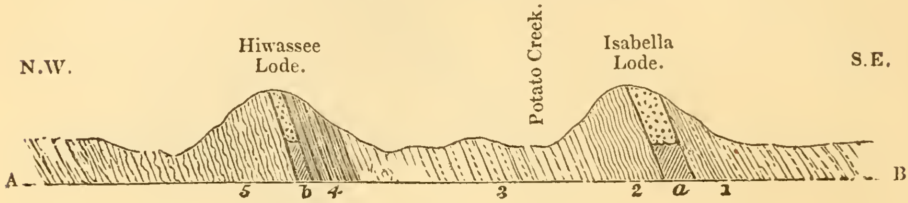
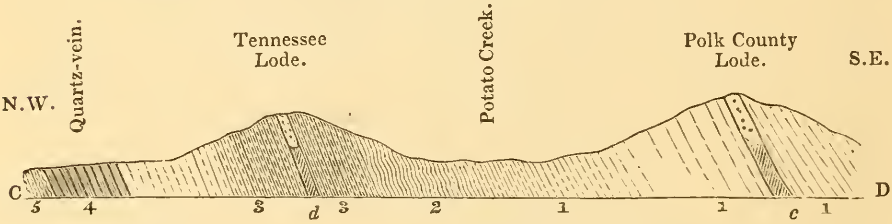


Fig. 6.—*Section from* C *to* D *on the Map, fig.* 4.



1. Blue slates.
2. Talcose schists.
3. Dark ferruginous schists.
4. Hard schists.
5. Talcose, steatitic, and garnetiferous schists.

blocks of spongy iron-oxide and hard lumps of magnetic iron-ore. In most cases these veins are nearly vertical, or dip slightly to the south-east.

Within the narrow belt represented in the map (occupying about four miles in length by one-and-a-half in breadth, or six square miles), there are four very remarkable outcroppings of porous iron-oxide, which together form the subject of the present memoir. Two of them are approximately parallel in the northern, and two others in the southern part of the district. They are of very unequal extension in length of outcrop, and of very unequal width. They are connected more or less distinctly by quartz-strings, of which there are many in addition to those marked in the map. They are occasionally accompanied by solid ribs of quartz, forming a foot- or a hanging-wall. They all dip to the south-east, the angle varying in different parts of the same lode. In all of them the surface appearance presented by the gossan is that of a mass of cellular iron-oxide, with more or less quartz, forming the walls of the cells, and the proportion of peroxide of iron is so large, that under ordinary exposure the mass of outcropping mineral presents a rusty appearance of naked rock with little or no soil, so that its dimensions can be easily and accurately measured. In other cases, where soil is formed upon it, the colour is so deep a vermilion as to mark at once the nature of the underlying rock.

The exact condition of the rocks enclosing the veins and lodes is by no means easy to determine, as they are covered by vegetable soil and a growth of forest-trees. On the banks of the Ocooee towards the north-west, the rocks seen consist of felspathic porphyries with quartz-veins, alternating with numerous varieties of schist and blue slate. Overlying these are magnesian rocks, consisting of talcose and steatitic schists, which seem to abound especially in the metalliferous portions of the country. Micaceous schists are also common, and garnet-schists are characteristic of some particular localities. Among the minerals common in the veins may be mentioned cyanite, of which I saw large quantities,—epidote, not so abundant,—and common garnets, often extremely plentiful.

Some idea of the country will be obtained by referring to the two sections, figs. 5 & 6, and the accompanying map, fig. 4, p. 247, but much detailed observation would be needed to insert accurately the limits of the various metamorphic rocks, and determine the mode in which they pass from one to another variety of schist and porphyry.

It will be seen by reference to the map that of the four gossan-lodes the length varies from 600 yards to upwards of a mile. The width is still more variable, ranging from 6 or 7 to 40 or 50 feet in three of the number, and in the fourth averaging as much as 250 feet. These dimensions have been actually proved either by the outcropping gossan or by workings on the lodes at a small depth. Wherever throughout the district any portion of these gossans has been sunk through to sufficient depth, they have been found to terminate downwards in a variable thickness of black soft copper-ore, which analysis shows to be derived from the decomposition of copper-pyrites. The distance of this deposit from the surface varies from 5 or 6 up to about 90 feet, and often seems to have some imperfect correspondence with the form of the ground, being usually smallest in the valleys and greatest on the crests of the hills. The outcrops are also narrowest in the valleys, at least in a majority of cases.

The black ore reposes on a very irregular floor of hard dense quartzose veinstone sparingly spotted with copper-ore, and largely impregnated with black and yellow copper-ore. In various parts of the mineral field this veinstone has been sunk through to different depths, but nowhere more than 18 fathoms. No very important change has been recognized thus far, but fair indications of copper-lodes of the ordinary kind are not wanting, and in one place beyond and to the south of the Tennessee gossan-lode there was a distinct change of ground noticed, and the veinstone became calcareous at a depth of about 17 fathoms from grass*.

The thickness of the black ore between the gossan and the floor of

* In this sinking the lode underlies from 15 to 18 inches in the fathom, its width appears to be between 30 and 40 feet, and the foot-wall appears to become softer on going down. The veinstone itself, however, remains extremely hard, and the stones of copper-ore obtained were too few to be of importance, even as indications. A thin seam of poor ore was found under the gossan, but where no quantity of iron-oxide was seen at the surface there was nothing worth removing below. In the Culchote mine the surface-indications were poor and small; but the underground appearances were more satisfactory. No profitable result has, however, been obtained as yet (June 1857).

hard rock varies from a few inches up to 18 feet, but when above 4 or 5 feet must be regarded as exceptional and local. In some of the lodes generally, and in some parts of all of them, pockets or bunchy deposits of ore either replace the bed of ore (the intervening portions being barren) or are only connected by a few inches of valuable mineral. Where bunches are common, horses of ground occur in the gossan, masses of schists or portions of the quartzy vein-stone projecting upwards into the gossan. Very rich deposits have been found where the seam of ore is interrupted by these barren portions of ground, both at the top of the horse and in holes in the hard mundic-rock. The thickness of the ore is often uniform or nearly so for a considerable distance, and in that case varies from $2\frac{1}{2}$ to 4 feet. Not unfrequently the bed of ore thins out and at the same time rises towards one wall of the vein.

It is almost impossible to determine the quality of the ore from its aspect. It is usually of a dirty black or deep velvet-black colour, moderately hard, but spongy and apparently a good deal decomposed. It is very readily got with the pick, and must all be brought out, as, while underground, there are no means of separating ore from rubbish. Some idea of the varied nature of different parts may be obtained from the following assays of six samples carefully taken by me from different heaps which presented but little difference to the eye. The assays were made by Mr. T. H. Henry, and show a mean of 26·2 per cent. of copper. No. 1 contained 14·9 per cent.; No. 2, 18·6; No. 3, 20·9; No. 4, 21·1; No. 5, 28·2; and No. 6, 53·4. In the latter there were, no doubt, lumps of black oxide. An analysis having been made by Mr. Henry of an average of these six samples, the result shows: sulphur, 29·47; copper, 26·73; iron 26·04; quartz, 8·60; oxygen and loss, 9·16. The mineral is therefore a sulphuret of copper and iron with a slight excess of oxide of copper. A certain loss of copper is the result of exposure to the weather or in any way to the action of water.

The four gossan-lodes I have named respectively *Hiwassee, Tennessee, Polk County,* and *Isabella,* these being the names of the properties on which they were first opened. The Tennessee is perhaps more properly regarded as a branch of the Hiwassee, but may be described separately. The relative position of the lodes will be seen by reference to the map, fig. 4, p. 247, and the sections, figs. 5 & 6, *a, b, c, d.*

The *Hiwassee lode* ranges nearly N.E. and S.W., dipping S.E. about 15 inches in the fathom. Its gossan is traceable for a mile and a half, commencing on the crest of a hill, and crossing two hills and three valleys. In each valley the width is greatly narrowed and the vein almost lost. The width for about half the length of gossan-outcrop is at least 30 feet. The ore is irregularly distributed, the thickness averaging about three feet, and it lies generally at a moderate depth (ten to twelve fathoms) on the hills, and close to the surface in the valleys. The south-western part of the lode has been much worked from two shafts, and at least 4000 tons of rich ore had been extracted at the date of my visit (1854).

Towards the south-west the vein is continued beyond the gossan-outcrop by strings of quartz, one in the direction of the lode and another making an angle of 25° to the south. The former is at first very large, but dies away at the surface. The latter is inconsiderable and hardly traceable for about three-quarters of a mile, but then presents another gossany crop, and forms the Tennessee lode. At several points where it has been proved by costeanings between the two gossans, it is seen as a thin string of quartz with no orey indications.

Towards the north-east the Hiwassee vein branches at a point on a hill-side, and from the bottom of the next valley (at the point marked *a* in the map, fig. 4, p. 247), it shows but an inconsiderable gossan. It has been opened on by shafts at two or three points beyond this; but, though containing black ore, the quantity is not large and the quality is inferior. A few hundred yards beyond, it passes off into thin quartz-strings, and is lost.

The south-western extremity of this gossan-lode adjoins a remarkable garnet-schist of great beauty. The north-eastern part shows an equally striking development of eurite and fine crystals of cyanite.

The *Tennessee lode* or branch ranges N. 20° E. and S. 20° W., dipping very variably to the S.E., sometimes being nearly vertical, and sometimes inclined at an angle of 45°. It commences as a gossan-lode near the crest of a hill, and crosses three valleys, generally appearing to diminish in value in the valley. It passes southwards into a quartz-vein of no importance. It is extremely irregular and bunchy, but has yielded some very rich ore, and in hollow cavities in the gossan very fine specimens of crystalline and arborescent native copper and crystalline red oxide of copper have been found. The bunches of rich ore in this lode have sometimes been found descending 12 to 18 feet into the comparatively barren veinstone below, or penetrating upwards to the same extent into the gossan.

The *Polk County lode* is nearly parallel to the Tennessee, and is one of a group of three or four veins near together, but with no other gossan than that which belongs to the lode itself. It has been traced for three-quarters of a mile, terminating abruptly to the north-east, and passing off into strings of quartz towards the south-west, one of which has traces of gossan. At some distance from the point where the large outcrop ceases, there is a cross-course of quartzy veinstone, making an angle of 60°. In the Polk County mine, whence a good deal of ore has been removed, the breadth is from 20 to 40 feet, and the thickness of black ore very irregular, but estimated to average 3 feet. In many places it has been observed, that the floor of black ore is not only not parallel to the slope of the hill, but rises towards the surface as the hill slopes down to the valley. There is evidently no accordance of the floor of ore with the form of the surface.

The *Isabella lode* is nearly parallel to the Hiwassee, but is the most remarkable of all in the district for its enormous width, which is estimated to average 250 feet. Its length, as marked by gossan, is about 600 yards, the whole of it being on the crest or eastern slope of one hill. The black ore is reached by adit-levels from the foot of the hill on the east side, and, judging from what has hitherto been extracted, is of inferior quality to the average from the other lodes. The gossan is also harder, and interspersed with magnetic oxide of iron in considerable quantities. The floor below the black ore is the usual mundicy veinstone, and the deposit less irregular than in the Tennessee and Polk County lodes; but the average thickness does not appear so great as in the Hiwassee vein.

As a gossan-lode this remarkable vein terminates abruptly at both extremities. To the north-east, at the point where the gossan terminates, there proceed three principal quartz-veins, nearly parallel, but slightly divergent, and of small size. The furthest to the west is the largest, and extends for some distance; the others seem to die away. To the south-west, one main branch of large size, bearing gossan, turns due south for a short distance, but soon passes into a quartz-string, alters its direction, and disappears. Another principal branch, also of large size and having a good outcrop of gossan, takes a south-west direction, and presently turns more towards the west. Immediately it has passed the crest of the hill the gossan ceases, and it becomes a quartz-vein, in which form it is traceable for fully half a mile in a perfectly straight line. A third quartz-vein, between these two, extends for some distance, and connects by a remarkable quartz-knot with the quartzy strings from the Tennessee lode.

I have been minute in the description of these lodes and quartz-veins or strings on account of the exceptional character of the phænomena, which will be at once manifest to those familiar with metalliferous lodes in Europe. It may be well, however, to point out some of the important resemblances and differences.

These veins agree with ordinary metalliferous lodes,—1st, in having distinct walls approximately parallel, clearly separating the contents of the vein from the enclosing country. Thus enclosed, they range parallel to each other for some distance, not changing with the country, and not much affected by changes of the country; 2ndly, in having a defined crystalline veinstone, usually of quartz, but including sometimes calc-spar, passing towards the surface into more cellular quartz loaded with oxide of iron, such as is often found in other countries at the outcrop of the most important copper-lodes; 3rdly, in the limited extension of such veins in length and width, and their apparently unlimited depth; 4thly, in the fact that the principal lodes are accompanied by parallel lodes and branches; and 5thly, that the lodes are inclined to the horizon at a high angle, which in most cases is tolerably regular in the same lode, and often nearly vertical.

On the other hand, we find the following differences:—1. Instead of crossing and intersecting at a considerable angle the general range of stratified rocks in which they occur, these lodes are always approximately, and sometimes truly, parallel to the strike of the schists. 2. They not only agree with the stratified rocks in strike, but also in the direction, and even in the amount of the dip. 3. Agreeing with the stratified rocks in strike and dip, they not unfrequently contain within their defined walls portions of schist in their normal and unaltered condition, thus showing a true interstratification to that extent. 4. Between the gossany outcrop of the lodes and the hard solid mundicy veinstone below, is found a mass of black cupriferous ore, as already described, entirely distinct from either, and separable mechanically from both with the greatest facility. This deposit reposes on the floor of mundicy veinstone, filling its hollows, and apparently adapted to its irregularities of surface. 5. The width of the lodes in the majority of cases, and the depth of the black ore from the grass, are very distinctly affected by the present form of the surface, the lode being much narrowed in the valleys, and the thickness and width as well as quality of the black ore reduced, while the greatest depth at which this ore has yet been seen is very little indeed below the ordinary level of the valleys.

In the three first-mentioned points of difference, and sometimes in the fifth, the Ducktown veins are analogous to the auriferous quartz-veins (sometimes also cupriferous) of Virginia and North Carolina, and even those of California. In the first and third points they agree with the Maryland veins described in the previous notice, p. 242; but the fourth condition is altogether peculiar, and has not, so far as I am aware, been hitherto recorded. Analogy would point to the existence of similar black ores beneath the Maryland gossans.

These Ducktown lodes must not be considered without special reference to the physical conditions of the adjacent country. They are amongst the old rocks of the main Alleghany Chain, but not very near any large masses of igneous rock. The general form of the ground, as far as regards the ranges parallel to the main axis, is unquestionably due to elevatory causes, and not to denudation; but it would be difficult to decide, without very minute investigation, whether the transverse cuts through which the natural drainage is carried are partially or entirely the result of weathering and aqueous action or are due to transverse elevations. No faults or heaves have as yet been observed in the district, and no cross-courses are known that intersect the gossan-lodes.

No very satisfactory account has yet been given of these singular deposits. Mr. Whitney and some American geologists have attributed the existence of this band of decomposed copper-ore (which has been erroneously regarded as black oxide of copper) beneath the gossan and above the veinstone as an effect of the decomposition of the veinstone near the surface, and have seen in the curious arrangement of this bed near the present water-level a confirmation of their views. But, independently of the fact that the present veins could never by any possibility decompose into the present gossans and beds of ore, there is really no water-level to which they can be referred, as the floor of ore merely approximates in a general way to that of the natural drainage, and is often totally opposed to that direction. Whatever may have been the original condition and subsequent action, it appears to me certain that the filling of the part of the vein above the hard mundicy veinstone was a different and subsequent operation to that of segregating the veinstone itself.

The Ducktown ores seem, in fact, to be contained in a kind of stock-works produced as gaping fissures in stratified or partially metamorphosed rocks during metamorphism and elevation, and subsequently filled up by segregation from the enclosing country or from below during the completion of metamorphic action. These large lodes are connected with numerous smaller fissures filled only with quartz, the metallic sulphurets and oxides appearing to occupy the upper and less compact portions of the larger fissures. That the fissures were filled up by chemical forces and independently of direct aqueous action, is, I think, quite clear, and no modification of the theory of sublimation would account for the phænomena of the district.

As, however, some of the quartz-lodes in which there is no surface-gossan have been proved to contain gossan at a moderate depth (a few fathoms from the surface), and as in one case an effort has been made to reach copper-ores of the ordinary kind (yellow sulphurets) by sinking in quartz-lodes within the district, there may be an opportunity of judging of the nature of these lodes and their contents at greater depth. It seems to me by no means unlikely that large bunches of rich copper-ore may exist either in the gossan-veins beneath the hard floor, or in the quartz-veins where no gossan is presented to view at the surface; but, until experience has shown some result of importance, it would be unsafe to assume the presence of courses of ore in Ducktown such as are found in other known mining districts.

Very analogous cases of outcropping gossan of large dimensions have been discovered in Virginia about a hundred miles to the north, and specimens both of the gossan and of the underlying black ore were shown me by persons interested in these mines. I was unable to visit them, and therefore can do no more than direct attention to the fact.

March 11, 1857.

Charles Napier, Esq., C.E., and John Brown, Esq., York, were elected Fellows.

The following communications were read:—

1. *Description of the Lower Jaw and Teeth of an* Anoplotherioid quadruped (Dichobune ovina, Ow.) *of the size of the* Xiphodon gracilis, Cuv., *from the* Upper Eocene Marl, Isle of Wight. By Prof. Owen, F.R.S., F.G.S.

[Plate VIII.]

The subject of the present description (Pl. VIII.) is an almost entire lower jaw with the permanent dental series, wanting only the four middle incisors. The specimen is from the collection of the Marchioness of Hastings, and now forms part of the Palæontological collection in the British Museum. The dental formula, as shown by the mandibular teeth, and by the evidence on their crowns of the presence of the teeth of the upper jaw, is the typical one in diphyodont* Mammalia; viz., $i\,\frac{3-3}{3-3}$, $c\,\frac{1-1}{1-1}$, $p\,\frac{4-4}{4-4}$, $m\,\frac{3-3}{3-3}=44$. The canine, *c*, with a crown like that of the first premolar, *p* 1, and not longer, is separated from it by an interval of half the breadth of the crown and by a narrower interval from the outer incisor, *i* 3. The first premolar, *p* 1, is divided by an interval of scarce a line's breadth from the second, *p* 2. The rest of the molar series are in contact.

The total length of the lower jaw is 5 inches 11 lines ($0^{m}\cdot148$); that of the molar series is 2 inches 11 lines ($0^{m}\cdot075$); that of the three true molars is 1 inch $4\frac{1}{4}$ lines ($0^{m}\cdot035$).

The near equality in height of the crowns of all the teeth, and their general character, show that the animal belonged to that group of the Anoplotherioid family which includes the genera *Dichobune* and *Xiphodon* of Cuvier. The dentition of the present species differs from that of *Dichodon* in the absence of the accessory cusps on the inner side of the base of the true molars, fig. 3, *m* 1, 2, 3, and both from *Dichodon cuspidatus* † and *Xiphodon gracilis* ‡ in the minor antero-posterior extent of the premolars: it corresponds with *Dichobune* (as represented by the *Dich. leporina*, Cuv.§) in the proportions of the premolars and in the separation of the canine from the adjoining teeth: to this genus, therefore, the fossil is referable, provisionally, in the absence of knowledge of the molars of the upper jaw, which are the most characteristic; and I propose to call the species, from the size of the animal represented by the fossil, *Dichobune ovina*. The lower jaw differs in the broader or deeper horizontal ramus, and in the less oblique ascending ramus, from that of the *Dichobune leporina* figured by Cuvier ||.

The outer incisor, *i* 3, has a short and broad crown reduced by the attrition of the summit to a semioval shape, with the external convexity interrupted by a feeble concavity near the hind border, the inner side having the middle convexity passing into a slight concavity on each side; but it has no basal ridge and fossa, as in *Dichodon*. The crown is covered by a moderately thick enamel, well-defined from the fang.

The canine, *c*, has a similar, but larger and more pointed crown, with a very feeble indication of a hinder lobe, and deeper concavities before and behind the median convexity of the inner surface. The crown is worn at the summit and along the anterior slope, exposing a linear tract of dentine; it expands abruptly, before and behind, above the fang.

The first premolar, *p* 1, is smaller than the canine, but resembles it in shape, save in a less feeble indication of the hind basal lobe, the

* Philosophical Transactions, 1850, p. 493.

† Quarterly Journal of the Geological Society, vol. iv. June 1847, p. 36, pl. 4.

‡ Ossemens Fossiles, ed. 1836, tom. v. p. 105, pl. 133.

§ Ib. tom. v. p. 110, pl. 90. fig. 1. || Ib.

summit of which has been worn by an upper tooth; the chief cone is worn only along its anterior slope, as in the canine.

The second premolar, *p* 2, shows a marked increase of size, and chiefly of antero-posterior extent, which is $5\frac{1}{2}$ lines ($0^{m}\cdot011$), the height of the crown being 3 lines ($0^{m}\cdot007$). The hind basal lobe is well-marked: any trace of a front basal lobe has been worn off by the abrasion along the anterior slope of the main cone, which shows a linear tract of dentine: both the anterior and posterior depressions of the inner surface are well-marked. The second premolar of the *Dichobune leporina** differs from that of the present species in its well-marked anterior lobe. In both species this tooth is supported by two fangs.

The third premolar, *p* 3, of the *Dichobune ovina* is chiefly distinguished from the second by an increase of thickness and an indication of an anterior lobe: the crown of this tooth is abraded along its anterior slope and at the summit of the hind lobe.

In the fourth premolar, *p* 4, a second cone is developed on the inner side of the chief cone; this has also an anterior and posterior accessory tubercle, the anterior of which has a basal ridge. The summits of both principal cones and of both accessory cones are abraded in this tooth: its antero-posterior extent is less than that of the third or second premolar; but its transverse thickness is greater.

The first, *m* 1, and second, *m* 2, true molars consist each of two transverse pairs of cones; a third pair, the inner cone of which is minute, is added to the back of the third molar, *m* 3.

In the first molar, *m* 1, the two outer cones are worn down to near the base of the inner cones, which have only their summits touched. The outer cones have an almost equilateral triangular section with the outer angle rounded off and the inner side or base slightly concave. The inner cones are more compressed, with their outer side more convex than the inner one, which shows a feeble narrow depression near the anterior and posterior border, and a rudiment of an accessory lobule at the back part of the base of the anterior cone; fig. 3, *m* 1.

The second molar, *m* 2, resembles the first, but is rather larger; the summits of its outer cones are more worn than those of the sublanceolate inner cones.

The chief part of the third molar, *m* 3, closely resembles the second molar: its accessory division plainly consists of a pair of cones; the inner one being rudimentary, the outer one of the same antero-posterior extent as the normal outer cone, but lower and thinner, and oblique in its position.

The unequal wear of the true molars gives their grinding surface an aspect turned a little outwards; that of the premolars and canines shows that those compressed, conical, antero-posteriorly extended teeth are interlocked with similarly-shaped teeth of the upper jaw.

From the *Dichobune cervina* (which M. Gervais thinks, and I concur with him, may belong to the genus *Dichodon* †) described and

* Ossemens Fossiles, ed. 1836, pl. 90. fig. 2.

† " L'examen que nous avons fait de cette pièce dans les collections de la So-

figured in my 'British Fossil Mammals,*' the *Dichobune ovina* differs in the absence of the basal cusps of the inner cones of the true molars, and by the greater antero-posterior extent of the third molar, due chiefly to the greater proportional size of the hinder supplemental division of that tooth. The antero-posterior extent of the three true molars is 1 inch $2\frac{1}{2}$ lines ($0^{m}{\cdot}031$) in *Dich. cervina* ; it is 1 inch $4\frac{1}{4}$ lines ($0^{m}{\cdot}035$) in *Dich. ovina.*

The first and second true molars of the lower jaw are so nearly similar in size in the above two species, that the upper molar from the Eocene limestone of Binstead, Isle of Wight, of a true *Dichobune*, figured and described by me in the 'Proceedings of the Geological Society,' May 20th, 1846 (Quarterly Journal, vol. ii. p. 420), may belong to the present species (*Dichobune ovina*). And this will be the more probable, should upper molars of the generic type of *Dichodon*, answering in size to the lower molars of the *Dich. cervina*, be hereafter discovered in the freshwater marl at Binstead.

I proceed next to offer a few remarks on the genera *Xiphodon* and *Dichobune*, Cuv., and on the first appearance of true Ruminants in the fossil world, which have been suggested in the course of the comparisons instituted for the determination of the above-described lower jaw and teeth of *Dichobune ovina.*

Genus Xiphodon.

The genus *Xiphodon* was indicated, and its name proposed, by Cuvier, for a small and delicate, long- and slender-limbed Anoplotherian animal, which, in his first Memoir, 'Annales du Muséum' (t. iii. p. 55, 1803), he had called *Anoplotherium medium* ; but he altered the name, in the second 4to edition of the 'Ossemens Fossiles' (tom. iii. pp. 69 & 251, 1822), to that of *Anoplotherium gracile* †.

The distinction indicated by Cuvier is now accepted by Palæontologists as a generic one, and a second species (*Xiphodon Geylensis*) has been added by M. Gervais (Paléontographie Française, 4to, 1845, p. 90) to the type-species, *Xiphodon gracilis*, of which he figures an instructive portion of the dental series of both jaws, obtained from the lignites of Débruge, near Apt. The dental formula of *Xiphodon* is the typical one, viz. $i\,\frac{3-3}{3-3}$, $c\,\frac{1-1}{1-1}$, $p\,\frac{4-4}{4-4}$, $m\,\frac{3-3}{3-3}=44$.

The teeth are arranged in a continuous series in both jaws. The canines and first three premolars have the crowns more extended

ciété Géologique de Londres nous a conduit à penser qu'elle appartient au genre *Dichodon*, que M. R. Owen a établi pour une autre espèce du même dépôt, le *D. cuspidatus.*"—Zoologie et Paléontologie Française, 4to, pl. 35. Descript. p. 5.

* Page 440, fig. 181.

† "Elle diffère assez des deux premiers Anoplotheriums par les molaires, les antérieures toutes tranchantes, les postérieures d'en bas à croissans redoublés et parallèles, pour former un sous-genre dans ce genre ; et suivant un usage que j'ai introduit dans mes écrits zoologiques et dont je reconnais chaque jour davantage l'utilité, j'imposerai à ce sous-genre un nom particulier, *Xiphodon*, que je tire de la forme tranchante d'une partie de ses dents, de ξίφος et d'ὀδούς."—Ossemens Fossiles, ed. cit., tom. iii. p. 62.

antero-posteriorly, lower, thinner transversely, and more trenchant, than in the type-*Anoplotheria* (whence the name *Xiphodon*, or Sword-tooth). The feet are didactyle, with metacarpals and metatarsals distinct. The tail is short. The lower true molars have two pairs of crescentic lobes with the convexity turned outwards. But perhaps the most important proof of generic distinction from *Dichobune* and *Dichodon*, e. g., would be afforded by the modifications of the crown of the true molars of the upper jaw. With these I am acquainted only by the figures and descriptions given by Cuvier and M. Gervais.

An oblique view of the grinding surface of the true molars of one side of the upper jaw of *Xiphodon gracilis* is given by Cuvier in the pl. 14, *Supplement*, of the Original Memoir above quoted (pl. 52. ed. 1822); in which the inner cone of the front half of the tooth appears, in the second molar, to be separated from the outer cone by an intermediate ridge or cone of equal size with the outer one, and not of half that size, as in *Anoplotherium* proper.

The same tooth, *m* 2, in the figure of the five last grinders of the upper jaw of the *Xiphodon gracilis*, from Débruge (Paléontologie Française, pl. 34, fig. 2), shows also three cones on the anterior moiety of the crown, and M. Gervais, in his description of that figure, expressly says, it is given "pour montre les trois pointes ou pyramides de la colline antérieure et les deux pyramides de la colline postérieure." (Pl. 34. p. 1.) But in his characters of the genus *Xiphodon* (op. cit. p. 90) he cites "les arrières molaires à deux collines, formées supérieurement de deux pointes chacune, subarques et rappelant celles des ruminants."

Now, this character would apply to *Dichodon*, but it does not accord with the published figures of the upper true molars, or with his own description of one of those figures, of the *Xiphodon gracilis*.

The first and second lower molars have two pairs of lobes, the third having an additional hinder lobe; but that lobe appears to be simple, and the internal lobes of the normal pairs have not the accessory basal cusps, as in *Dichodon*. M. Gervais adds the following remark with reference to the affinities of *Xiphodon*:—"Ces dents (de l'*Hyopotamus porcinus*) sont à deux collines transverses, dont l'antérieure a trois pointes ou pyramides, et la seconde deux seulement. Elles indiquent une espèce intermédiaire à l'*Anthracotherium magnum* et à l'*Hyopotamus velaunus*, et montrent aussi que les Xiphodons sont des animaux très-voisins des Hyopotames." (Paléontologie Française, Description of pl. 31. p. 1.)

But the genera *Anthracotherium* and *Hyopotamus* differ, in the insulation of *p* 1 from both the canine and from *p* 2, from the genera *Anoplotherium*, *Xiphodon*, and *Dichodon*, in which the dental series is continuous.

Genus Dichobune.

The genus *Dichobune* (from δίχα, *bipartito*; βουνός, *collis*) was proposed by Cuvier, in the second edition of his 'Ossemens Fossiles,' 4to, tom. iii. 1822, p. 64, for the *Anoplotherium minus* of the original Memoir, in the 'Annales du Muséum,' tom. iii. (1803), and for the *Anopl. leporinum* of the 4to edition, 1822, tom. i. pl. 2. fig. 3, and tom. iii. pp. 70 and 251 *. It is closely allied to the Anoplotherioid genus *Xiphodon*; the dental formula is the same, only there is a slight interval between the canine and the first premolar in both jaws: the first three premolars are subcompressed, subtrenchant, but less elongated from behind forwards than in *Xiphodon*. Besides the two normally developed and functional digits on each foot, there be one, sometimes two, supplemental digits.

The best illustration of the structure of the upper true molars is, perhaps, afforded by the figure of one of these teeth in the 'Proceedings of the Geological Society,' May 20th, 1846, published in the 'Quarterly Journal,' vol. ii. p. 420. "The Anoplotherian character of the tooth is shown by the large size of the lobe, *p*, *x*, fig. 1, and the subgeneric peculiarity by the continuation of its dentinal base with that of the inner and anterior lobe, *i d*, at the early stage of attrition presented by the crown of the tooth in question. In the large and typical *Anoplotheria*, the lobe, *p*, preserves its insular form and uninterrupted contour of enamel until the crown is much more worn down (than in the present tooth, fig. 1). In this respect, as in the modifications of the lower molar teeth, the genus *Dichobune* shows its closer affinity to the true Ruminants; but the little fold of enamel dividing the lobe *i d* from *p* distinguishes the upper molar tooth in question from that of any Ruminant." (p. 421.)

Two upper molars, originally referred by M. Gervais to the genus *Hyracotherium* †, have since been figured by him, and referred, analogically, to his *Dichobune Robertiana* ‡. They unquestionably correspond more closely with the upper molar referred by me to the genus *Dichobune* than to the upper molars of *Hyracotherium*. They show, as M. Gervais describes, "cinq pointes tuberculeuses placées sur deux rangs, trois au premier rang et deux au second." (p. 6.)

In the characters of the genus *Dichobune* given by M. Gervais in the text, he describes the upper true molars as formed "de deux rangs de pyramides obtuses; deux pyramides en avant ou au premier rang et trois en arrière, c'est-à-dire au second rang."

Whether this ascription of the three cones or points to the hinder, instead of the fore, division of the molar tooth be based upon an observation of those teeth *in situ* in the upper jaw, or upon the analogy of the *Microtherium* (*Cainotherium*, Lartet) is not stated. The teeth of the *Dichobune Robertiana* were found detached in the marl of the "calcaire grossier": the upper molar from the Binstead Eocene, referred by me to the genus *Dichobune*, was also a detached specimen. Entire crania of *Microtherium*, from the lacustrine calcareous marls of the Puy-de-Dôme, are in the British Museum, and these

* "Elle formera aussi pour moi le type d'un sous-genre que je nommerai *Dichobune*, à cause de ces pointes ou collines disposées par paires sur les quatre dernières molaires."—Ed. cit. p. 64.

† Compte Rendu de l'Académie des Sciences, t. xxxi. p. 552.

‡ Paléontologie Française, pl. 35. fig. 12.

clearly show that the *hinder* division of the upper true molars was complicated by the additional (third) cusp. So far as I have any knowledge of the specimens, or recorded specimens, of *Dichobune*, there are no better grounds than analogy for determining which is the fore and which the back part of the detached upper molar teeth. According to the *Anoplotherium* and *Xiphodon*, the three-cusped division would be the front one; according to the *Microtherium*, it would be the hind one. The modification of the molar described and figured in the 'Quarterly Geological Journal,' vol. ii. p. 420, is such, as, from subsequent knowledge of the teeth of extinct Artiodactyles, to confirm me in the choice of the analogy of the *Anoplotherium*, in determining the fore and back parts of the crown of that upper molar.

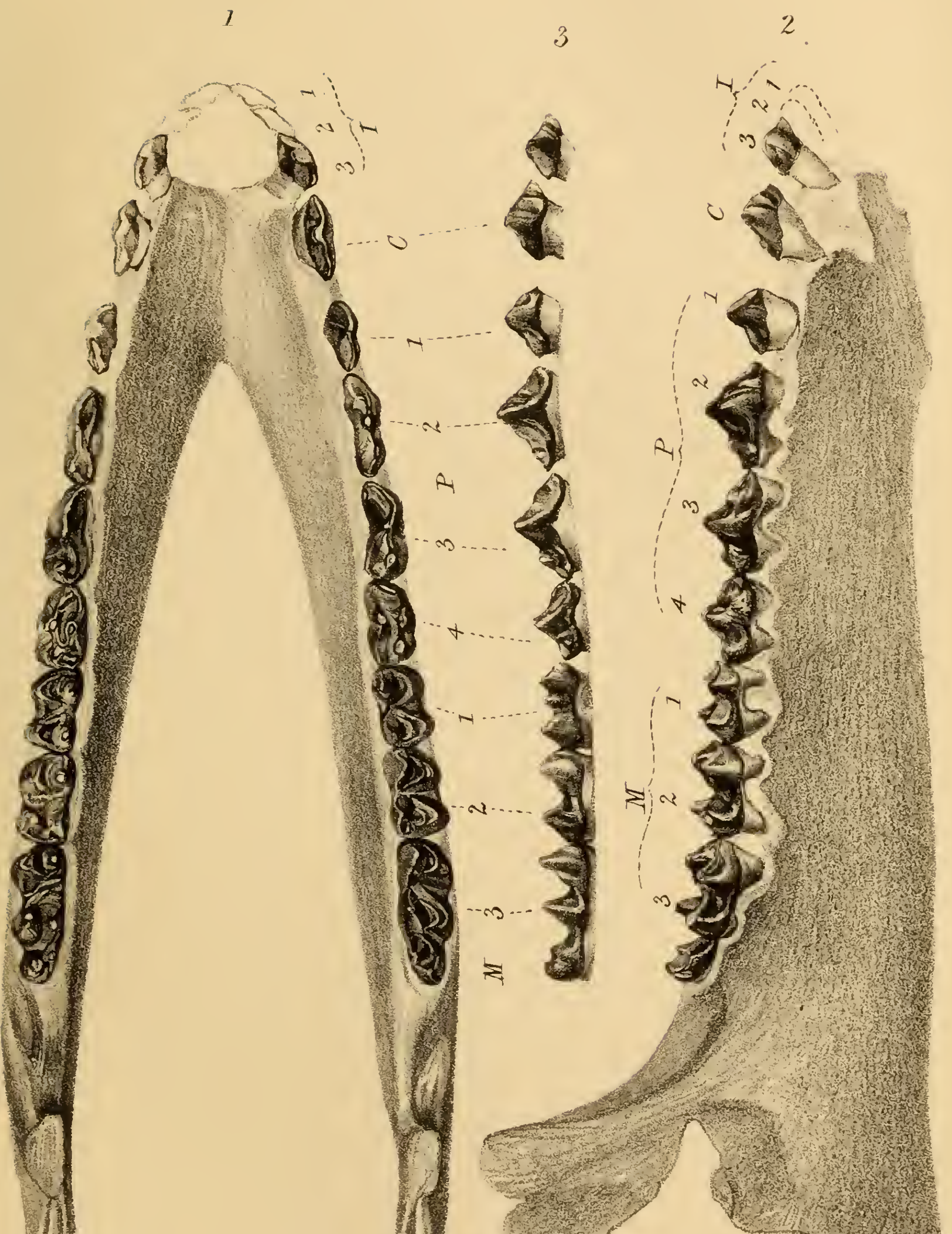
With regard to *Microtherium*, the unusually perfect fossil skulls of that small Herbivore, which did not exceed in size the delicate Chevrotains of Java and other Indo-Archipelagic Islands, e. g. *Tragalus Kanchil*, are of importance in regard to the question of the first appearance of the *Ruminantia*, on account of the demonstration they give of the persistent and functional upper incisor teeth. The little Eocene even-toed Herbivores, like the larger Anoplotherioids, thus departed from the characters of the true Ruminants of the present day, in the same degree in which they adhered to the more general type of the Artiodactyles. Had M. de Blainville possessed no other evidence of the *Microtherium* than of the *Dichobune murina* and *Dichobune obliqua*, Cuv., he would have had the same grounds for referring the *Microtheria*, as the *Dichobunes*, to the genus *Tragulus* or *Moschus* (les Chevrotains): but the entire dentition of the upper jaw of the species *Anoplotherium murinum* and *A. obliquum*, referred by Cuvier to his genus *Dichobune*, must be known, before the existence of Ruminants in the Upper Eocene gypsum of Paris can be inferred.

No doubt the affinity of these small Anoplotherioids to the Chevrotains was very close. Let the formative force be transferred from the small upper incisors to the contiguous canines, and the transition would be effected. We know that the Ruminant stomach of the species of *Tragulus* is simplified by the suppression of the psalterium or third bag: the stomach of the small Anoplotherioids, whilst preserving a certain degree of complexity, might have been somewhat more simplified. The certain information which the gradations of dentition displayed by the above-cited extinct species impart testifies to the artificial character of the Order *Ruminantia* of the modern systems, and to the natural character of that wider group of even-toed hoofed animals for which I have proposed the term ARTIODACTYLA.

DESCRIPTION OF PLATE VIII.

Lower jaw and teeth of *Dichobune ovina*, nat. size.

Fig. 1. Upper view, showing the grinding and cutting surfaces of the teeth; ideal outlines of the four anterior incisors are added.
Fig. 2. Outside view of the lower jaw and teeth.
Fig. 3. Inside view of the teeth.



[from] Nature on Stone by ... Erxleben
Day & Son Lithrs to the Queen

Dichobune ovina. (Nat. Size.)

2. *Description of* Two Species *of the* Fossil Mammalian Genus Plagiaulax *from* Purbeck. By H. Falconer, M.D., F.R.S., F.G.S.

Until very lately, the only fossil mammifer known to science from the Upper Oolite beds (Purbeck series) was the *Spalacotherium tricuspidens* of Professor Owen, a small insectivorous form referred by him, with some reserve, to the placental series*. It was discovered by Mr. W. R. Brodie in one of the so-called "Dirt-beds" of Durdlestone Bay, Purbeck. That meritorious collector continued his researches during the years 1855–56, and had the good fortune to discover some other mammalian remains, which were transmitted to London about the end of last December for description by Professor Owen. They were all found in what is called the "Dirt-bed" No. 93, of Austen's "Guide." Before these remains had reached London, Mr. Samuel H. Beckles, so favourably known from his researches in Sussex and the Isle of Wight, after free communication with Sir Charles Lyell about the importance of a close and sustained search for mammalian remains at Purbeck, proceeded to Swanage for the express purpose of carrying it out. Before a fortnight had elapsed, Mr. Beckles, by a series of well-directed excavations, had discovered several mammalian jaws besides numerous reptilian remains, in the "Dirt-bed" No. 93. When the first line of section ceased to be productive, or could no longer be worked, he opened new ground, under difficulties which would have damped the ardour of a less earnest inquirer. The labours of Mr. Beckles have been crowned with the success which they deserved. He has discovered a large number of mammal remains, many of which are new, and in very fine preservation. The united acquisitions of Messrs. Brodie and Beckles have already attained the important figure of about thirty mammalian jaws, more or less complete, the majority of them lower, but two, at least, upper jaws, with one well-pronounced cranium. The most important portion of these are the discovery of Mr. Beckles.

The explorations have been conducted under a conjunction of unusually favourable circumstances. Sir Charles Lyell gave his sage and long-experienced advice with the deep interest in the case which befits the author of the 'Principles of Geology;' Professor Owen aided the good cause by keeping Mr. Beckles advised of the importance of the additions which he was making to Palæontology; and, having had the leisure, from confinement to my rooms by indisposition, to examine the objects as they were successively discovered and forwarded to me, I was enabled to communicate to Mr. Beckles, constantly, an approximative opinion as to the nature of each fresh acquisition, and thus encourage him to persevere. From his correspondence, apart from the results, I can bear testimony to the rare zeal, minute care, and admirable vigour with which Mr. Beckles has followed up the inquiry. So productive have his labours been latterly, that hardly a week passes without its regular instalment of a couple of dispatches of mammalian jaws from Purbeck.

* Quarterly Journal of the Geological Society, vol. x. pp. 431 & 432, 1854.

It is intended that, when the collection is completed, the Purbeck Fossils shall be made over to Professor Owen for description and publication; and, from what is already manifest, it may safely be stated, that they will furnish materials for one of the most interesting and important of the many chapters which our distinguished countryman has contributed to the record of Mammalian Palæontology. Without forestalling Professor Owen's detailed results, I may be permitted to state that I have satisfied myself of there being among the Purbeck fossils at least seven or eight genera of Mammalia, some of them unquestionably Marsupialia, both predaceous and herbivorous; and others of them conveying to my mind the impression, so far as the evidence goes, that they belong to the Placental Insectivora, having affinities more or less remote to existing types.

Having undertaken a description of one of the most remarkable of these Purbeck mammal genera, in compliance with the expressed wishes of Mr. Beckles, to accompany some illustrations which will appear in Sir Charles Lyell's forthcoming Supplement to the 5th edition of the 'Manual of Elementary Geology,' I have thought it desirable to place the anatomical evidence for the results more in detail than could be admitted in a brief abridgement in that work.

The genus "*Plagiaulax**," which is inferred to have been herbivorous and marsupial, comprises two well-marked species, *Pl. Becklesii* and *Pl. minor*. It has been determined upon two distinct specimens, which were among the earliest of Mr. Beckles' acquisitions, each a right ramus of the lower jaw. Latterly, two additional specimens † have been received of the larger form, *Pl. Becklesii*, supplementing important points of evidence which were wanting in the first instance. The illustrations and descriptions now submitted, are derived chiefly from the two original specimens. Of these, the one of *Plagiaulax Becklesii*, (figs. 1 & 4, *a*, *b*, and *c*, *d*), in two pieces on reversed slabs, consists of the lower jaw, right side, perfect from the tip of the incisor to the proximal surface of the condyle, including the ascending ramus and coronoid, with the exception only of the raised posterior lower margin and inflected angle; it shows three premolars (*p*, *m*) *in situ*, with the empty sockets of the two back molars. Another specimen (fig. 7), fortunately supplies these two back molars *in situ*. The lower jaw (also of the right side) of the other species *Plagiaulax minor*, fig. 15, is less perfect. It contains all the teeth *in situ*, beautifully preserved, but it is mutilated vertically behind the alveolar border; the ascending ramus, with all the proximal portion, being wanting. Besides the two true molars, it contains four premolars instead of three, as in the other species.

Teeth.—Together, these specimens furnish nearly complete evi-

* An abbreviation for "Plagiaulacodon," from πλάγιος, *oblique*, and αὖλαξ, *groove*, having reference to the diagonal grooving of the premolars.

† A fifth specimen, subsequently acquired, is described in the sequel (See fig. 14).

dence as to the characters of the lower jaw of the genus. And, first, in regard of the teeth, the dental formula is,—

incis. $\overline{1-1}$; can. $\overline{0-0}$; prem. $\overline{3-3}$; mol. $\overline{2-2}$ = 12 in *P. Becklesii.*
$\overline{4-4}$ = 14 in *P. minor.*

To save unnecessary technical details, by reference to a well-known existing genus, which will constitute in other respects an important term of comparison, it may be stated at once, that the incisor of *Plagiaulax Becklesii* (fig. 1, *a*, & fig. 14), in every particular of form, namely, edge, point, and section, and in relative amount of projection, bears a very close general resemblance to the incisor of the marsupial *Hypsiprymnus*, or Kangaroo-rats, of Australia; it differs chiefly in being, for the relative size, more robust in the fossil animal, and curved more abruptly upwards. Its line of implantation in the socket is more vertical, and the alveolar sheath shorter and thicker. The diasteme is exceedingly abbreviated, not exceeding a line in length.

The three premolars, in *Pl. Becklesii* (fig. 1, *p*, *m*), are in the finest state of preservation, showing the details of every minute character. They are limited to three in all the specimens (see figs. 4, 11, 12, & 14). This is a point of some importance to establish distinctly, as there are four of these teeth in the other species. They form a closely adpressed and compact series of very unequal size, diminishing rapidly in succession from the last to the most anterior. The last premolar (*k*) presents a square oblong side, convex from back to front, and sloping upwards and inwards to the edge, which is finely serrulated, as in *Hypsiprymnus*, the serratures being caused by the terminations of about seven well-marked parallel grooves, which descend upon the side, not vertically as in *Hypsiprymnus* (fig. 6, *l*), but diagonally downwards and forwards, disappearing about the middle of the crown-side, upon a smooth and discoidal surface. The enamel below the four last grooves is inequal and raised into a well-marked crenated step (fig. 1, *k*), which is exhibited on all the specimens. The interior surface being adherent to the matrix, the characters of the inner side of the last premolar are not shown by this specimen. But in two of the other specimens the inner surface of all the premolars is free and seen to be furrowed by diagonal grooves, exactly like the outer, the principal difference being that the inner side is more flattened, and the enamel smoother than on the outer. The two sides, therefore, slope from the base upwards to a sharp or thin edge, which is serrulated, agreeing in every respect, except the inclination of the grooves, with the corresponding tooth of *Hypsiprymnus*. The tooth is implanted by two distinct fangs. The penultimate premolar is somewhat spathulate in outline, the lateral surface of the crown is convex in the longitudinal direction, and slopes inwards to the apex, which is diagonally grooved like the last premolar, the grooves being fewer in number. It is inserted by two inequal fangs, the posterior of which is barely visible; in size it corresponds with one fang division of the last premolar. The antepenultimate or anterior premolar is greatly reduced in all its dimensions, being hardly one-fourth the size of the tooth immediately behind it; in form it exhibits more the ordinary appearance of an incisor.

In the other species, *Plagiaulax minor* (fig. 15), which is very considerably smaller, the incisor (*a*) presents a corresponding general form, but it is more elongated, less robust, and is not so much curved upwards. A portion of the point has been broken off in the specimen, and it is seen by the impression (*a'*) that the inner side near the apex was hollowed out in a longitudinal depression. The premolars, in number four, are higher in proportion to the depth of the jaw than in the other species. The last one is similar in form and grooving to the corresponding tooth in *Plagiaulax Becklesii*, but exhibits a slight difference in the inequality of the enamel-surface below the basal terminations of the grooves. In front of it there are two spathulate premolars, *i. e.* the antepenultimate and penultimate, both diagonally grooved near the apex; and at the base of the antepenultimate, but pressed somewhat inwards, there is a very minute anterior or first premolar. The basal enamel-surface bulges out over the fangs in these teeth in a rounded angle which points downwards. Regarded as a series, they decrease in size very rapidly from the last to the foremost. The sharp edge of the crowns of the three anterior teeth slopes down towards the diasteme from the anterior margin of the last premolar; while that of the latter slopes in a reverse manner downwards and backwards towards the true molars, the anticlinal planes meeting at an obtuse angle.

The true molars in both species were limited to two, the sockets of which alone remain in the more perfect jaw (figs. 1 & 4, *m* and *i*). But they are shown *in situ*, in the most perfect preservation, in the jaw of *Plagiaulax minor* (fig. 15, *m*). It is clearly apparent from the relation of the second tooth to the mutilated base of the anterior margin of the ascending ramus (*b*) in the latter, and from the empty sockets of the fallen teeth in the alveolar rim of the perfect specimen (fig. 4, *i*) of *Pl. Becklesii*, that the true molars in the lower jaws of both species did not exceed two, a very unexpected and reduced number, to occur in forms otherwise inferred to be marsupial, and therefore demanding rigorous determination, there being no other corresponding instance known within the whole range of this subclass, fossil or recent.

Fortunately the specimen represented by figs. 1 & 4 shows the whole of the teeth of *Pl. Becklesii* in nearly as perfect preservation as they are in the specimen of *Pl. minor* (fig. 15). It consists of a right lower jaw in two continuous fragments, presenting the two last molars of an adult animal, well worn and *in situ*. The anterior edge of the ascending ramus is entire, forming a well-defined boundary to the alveolar border, and so closely contiguous to the second and last true molar, which it partly overlaps, that it is manifest, there could not have been more than two of these teeth in the jaw. The true molars are not only reduced in number in *Plagiaulax minor*, but they are also dwarfed in size, and comparatively insignificant in contrast with the last premolar, the united length of the two being less than that of the latter, while the vertical height of their crown is little more than one-third of that of it. They are situated both horizontally and vertically in different planes from the premolars; a perpendicular from the acute serrated edge of the latter would coincide with the line of the inner row of the crown-lobes of the true molars, to be described in the sequel, as occurs in the recent *Hypsiprymnus*; and the outline of the coronal surface of the whole molar series would be included within a curve, of which the last premolar formed the most salient part, with a considerable descent on either side of it.

The crown of the first true molar in *Plagiaulax minor* (fig. 15, *c*), which I take first as the more perfect, is of a broad oblong form. Its inner or axial margin supports two well-raised and bluntly conical points or tubercles, separated by a wide cleft, which is partly continued down upon the body of the tooth, vertically in a sinus, forming an obsolete mesial constriction. The points are isolated and start up in considerable relief. The outer edge of the crown is not divided correspondingly: it supports mesially but a single prominent conical tubercle, which is intruded upon the plateau of the crown, and opposed to the sinus between the two inner points. It alternates therefore with the latter. The base of the outer point is continued on either side, backwards and forwards, in a well-marked lunate bevelled rim, which is convex outwards, and rises at either end into a low terminal lobule. The posterior lobule may be considered as the homologue of the posterior inner point, although it forms but an insignificant tubercle. The anterior lobule is still less developed, but opposed to the anterior inner point. The middle of the crown is occupied by a sinuous hollow surface, intervening between the outer and inner rows. This hollow, from the intrusion of the outer mesial point and the constriction of the inner side, is divided into an anterior and posterior discoidal depression. The two rows are separated at both ends of the tooth by a longitudinal chasm. There is no indication of any low transverse concave ridge connecting the opposed tubercles. From the above description it will be seen that the two sides are unsymmetrical, whether the outer row is considered as consisting of a single point with an accessory tubercle on either side, or of three unequal tubercles.

The second or last true molar (fig. 15, *d*), viewed in profile, is smaller than the first, and the crown-surface, although of nearly equal extent, is less complex in its subdivision. It is of a broad oval, with the base applied to the contiguous anterior tooth. The coronal eminences consist of an outer and inner raised marginal and more or less lobulated edge, separated by a broad central depression. The outer edge is very narrow and nearly horizontal, rounded off at either end, and presenting no marks of composition beyond four or five obscure indications of crenulation, like one of the rows in the tooth of *Microlestes* (see fig. 16). It is incurved so as to overarch slightly the central depression. The inner edge presents at its anterior end a well-elevated and isolated conical tubercle, resembling in size and form the outer mesial point of the first true molar. It is bounded posteriorly by a deep wide cleft, from which a convex edge is continued backwards, which is raised, but not sufficiently to attain the importance of a cusp, although homologous to the rear cusp of the anterior tooth. The centre of the crown is occupied by a hollow—smooth, and, as it were, scooped out, and depressed considerably below the raised margins. A well-marked chasm intervenes between the marginal edges, both in front and behind, the latter being narrower and less pronounced, so than when the tooth is viewed endwise, the opposite rows are seen apart somewhat as in the tooth of *Microlestes*. The crenation of the outer margin into a row of tubercles is more decided in *Microlestes** (fig. 16), the crown is narrower and more elongated in proportion, and the opposed rows are more approximated. None of the raised points of these teeth in *Plagiaulax minor* show any considerable marks of abrasion, nor exposure of the ivory: the white spots in the figures represent adherent specks of matrix, and not depressed discs of wear; the apices of the outer crenations alone are a little worn in the last molar. The animal from which the fossil was derived is inferred, from the intact condition of the molar teeth, to have been a young adult, as these teeth have been found well worn in one specimen of the other species.

In the jaw of *Plagiaulax Becklesii* (figs. 1 & 4), there are three small pits on the alveolar border of the hind fragment (*c*, *d*), behind the last premolar. The anterior two, seen upon the fragment fig. 1, *a*, *b*, are closely approximated, with a thin plate intervening, indicating that they are the sockets of the two-fanged first molar. One of them is shown in the niche at the apex of the vertical sections, figs. 2 & 3, *f*, *g*. The last pit, fig. 4, *i*, is larger, square, and undivided, but showing obsolete marks of a mesial constriction, and indicating that the second or last molar had fangs converging in a common socket. The rim of this socket is distinctly defined, and the inner wall raised into a prominent gibbosity which leaves a deep impression on the matrix. This gibbous point corresponds with what occurs in the lower jaw of the recent *Hypsiprymnus Gaimardi*, with which it was compared, and is commonly seen on the alveolar wall of the last molar of other animals.

In the second specimen of *Plag. Becklesii*, figs. 7–10, already referred to, the two true molars of an adult and, judging by their wear, well-aged animal, are seen *in situ*. They present the same general characters as the corresponding teeth of *Plag. minor* (fig. 15), but appear to be proportionally larger, in comparison with the premolars. The crown of the first molar bore, as in the other species, three principal points, two to the inner row; and to the outer a single tubercle, which is situated more anteriorly than in *Plag. minor*. The outer point is worn down and indistinctly defined, the wear involving what appears to have been the bevelled lunate rim at the posterior end, as described in the other species. It is not determinable whether it

* I am indebted to Sir Charles Lyell for the only available means of instituting a comparison of these mammalian teeth from Purbeck with those of the *Microlestes* of Plieninger. Besides several duplicate casts, he had very careful and highly finished drawings made of the teeth during his last visit to Stuttgart, the whole of which have been placed at my disposal.

attained the magnitude of a separate tubercle. The two inner points form obtusely conical tubercles, which are in greater relief, and less affected by wear; so that the worn disc of the outer row shows like a step at their base. Of these tubercles the anterior bears an accessory lobe which is continued across in a front talon, giving a bilobed character to the point, which is but slightly abraded at the apex; while the posterior point shows a well-marked depressed disc, which is continued some way down upon the inner side of the enamel, as if caused by the grinding play of an overlapping cusp of an upper tooth in use against it. The longitudinal furrow between the two rows is distinctly visible. There is a well-defined basal cingulum to the last molar in this species. The inside elevation of the last true molar agrees very closely with a corresponding view of the larger tooth of *Microlestes antiquus*, as represented in one of the drawings belonging to Sir Charles Lyell (fig. 17, *c*). The second and last true molar presents a nearly square crown with rounded angles. It is fully equal in size to the penultimate, if not a little larger. The crown bears two marginal edges, as in the other species, with a well-marked depression between them. The inner edge is broken off and seen imbedded in the matrix of the opposite slab. The outer edge is entire, but ground down by wear, so that it shows a marginal band with no remains of crenation. The detrition of the crown, as a whole, bears some resemblance to that seen upon the last molar of an aged Bear; the comparison, be it understood, not being intended to imply the slightest idea of affinity. The angle formed by the anticlinal planes of the crowns of the true molars and premolars is more acute in the jaw of *Plag. Becklesii* than in that of *Plag. minor*.

Character of the Lower Jaws.—Although the teeth are seen in greater perfection in the latter species, the other characters of the jaw are best shown by the specimen of *Plag. Becklesii*, figs. 1 & 4, *a*, *b*, & *c*, *d*. The jaw, right ramus, is broken vertically through one of the sockets of the first true molar; the anterior fragment (*a*, *b*) presents the outer surface of all in front, from the last premolar, while the posterior fragment (*c*, *d*) exhibits the inner surface of all behind, on to the condyle. A very distinct impression of the premolars attached to the anterior piece, is left on the matrix of the slab which contains the hind fragment, so that it has been easy, by combining the figures, to produce a restored outline of the general contour, which is shown by the aid of dotted lines, in both figures, magnified twice the linear dimensions *. The most striking characters are: 1st, the shortness of the jaw from the posterior edge of the ascending ramus to the border of the alveolar sheath of the incisor (*a*); 2nd, the great vertical height of the horizontal ramus in relation to the last dimensions; 3rd, the depressed position of the condyle (*d*), and its great horizontal projection behind the coronoid process. The lower border of the *body* deviates little from the horizontal, for about four-fifths of its length,

* See also fig. 14, p. 280, illustrating a perfect right ramus of a younger individual magnified four times.

being but slightly convex. The upper margin slopes a little downwards from behind the premolars on to the incisive alveolus, so that, if the two margins were produced, they would meet at an acute angle. The diasteme is very short. The incisor (*a*) is comparatively large and directed suddenly upwards, the point being elevated above the level of the premolars, with a short bluff sheath-border. The base of the incisor is impressed with a shallow longitudinal fossa, and the upper edge is bevelled. The point shows no mark of abrasion. The mentary foramen is small, indistinct, and situated mesially in a line nearly with the middle of the diasteme. The alveolar border rises in large serrate processes between the fangs. The dark-shaded depression behind the vertical fracture (*b*, *c*) upon the matrix (*o'*, *d'*, *e'*), marks the position of the pointed gibbosity on the inner side of the alveolus of the last true molar (*i*). It is considerably below the line of implantation of the premolars, indicating that the true molars were placed correspondingly low, as is seen in the jaw of the other species. The longitudinal medial shade shows a deeply impressed broad channel upon the outer surface of the ramus, which is most pronounced under and behind the last premolar. The amount of this depression is well exhibited by the vertical sections (figs. 2 & 3, *f* & *g*), where (*x*) represents the inner surface, and (*y*) the outer. It is seen that the inner surface is slightly concave in the vertical direction, between the upper and lower margins; and that the general convexity of the outer surface is interrupted by a wide and deep fossa, causing a mesial constriction (*y*). Although there is as yet no direct evidence to the point available, in consequence of the outer surface of the posterior portion being adherent to the matrix, still it would appear that this channel runs back towards the depressed disk of the outer surface of the ascending ramus, although it may not have been continuous with it.

The posterior fragment (*c*, *d*, fig. 4) shows in very perfect preservation, the whole of the inner surface of the ascending ramus and condyle, with the exception of the fragile edge of the inflected lower margin and angle, which are broken off and left in part imbedded in the matrix-cast of the opposite slab containing the anterior fragment; it comprises also the posterior portion of the *body*, in which the last molar is implanted. The coronoid process (*e*) is triangular. Its anterior border slopes upwards and backwards to the apex in a gentle curve, at an angle of about 45° with the alveolar border. The posterior margin descends in a curve with little deviation from the vertical into the broad sigmoid notch (*d*, *e*), which is but slightly overarched by the apex*. Its height and width at the base are nearly alike, and about equal to the depth of the *body* of the jaw, in a line with the last molar. The apex of the process is sharp. In general form the coronoid process in *Plagiaulax* resembles more that of the predaceous marsupials, and of the Ursine *Dasyurus* especially, than that of the herbivorous families. It differs very markedly from the

* The artist has represented the posterior margin of the coronoid with too crescentic a curve, and the point projecting too much backward over the sigmoid notch.

elevated strap-shaped coronoid of *Hypsiprymnus* and the other herbivorous marsupials. It is to be remarked, however, that it is less elevated, and that its surface is of less area, than in the predaceous genera, whether marsupial or placental.

Fortunately the condyle (*d*, fig. 4) is, in every respect, as perfect as that of a recent bone. The matrix has been removed, so that it stands out in bold relief, showing the convex articular surface entire. In no part of the specimen are the peculiar characters of the fossil more strongly marked than in this process, the remarkable points being: 1st, its very depressed position, the upper edge being below the line of the alveolar border, and the lower extending nearly to the inferior margin of the jaw; 2nd, its prominent convex surface, great depth in proportion to the width, and vertical direction; 3rd, the breadth of the sigmoid notch (*d*, *e*), involving a long neck to the condyle, and its projection much behind the coronoid process. The articular surface is convex and protuberant, narrow in comparison to the height; when viewed endwise, the outline is pyriform, the broad end being uppermost. The general direction of the articular surface is vertical; a chord through the upper and lower edges of the curve would form a very acute angle with a perpendicular immediately behind it. The neck-portion of the sigmoid notch (*d*, *e*) is as long as the breadth of the coronoid, so that the articular surface is not only depressed below the apex of the coronoid, but projected a long way behind it. A line drawn from the condyle to the gibbous prominence on the wall of the last molar (*i*) considerably exceeds the length of the horizontal ramus from the latter point on to the border of the incisive alveolus. The inner surface of the ascending ramus behind the orifice of the dentary canal (*n*) is smooth, and near its inferior border traversed by a longitudinal channel which bends back to the under edge of the condyle. The orifice of the canal (*n*) is low and directly in a vertical line with the posterior wall of the last molar, being relatively situated exactly as in *Hypsiprymnus*. The anterior margin of the canal forms a raised step, the edge of which is continued upward in a low crescentic ridge to join on with the base of the gibbous prominence of the last alveolus. The mylo-hyoid groove traverses the ridge about the middle, but the adhesion of the inner surface of the front piece (*a*, *b*) to the matrix does not at present admit of its being determined how far the groove advances upon the horizontal ramus. The inner surface of the coronoid is convex, which is partly obscured by the plate of the process being traversed by numerous fissures, with partial displacement of the pieces.

The inferior margin of the hind part of the ramus is nearly horizontal; it terminates suddenly in the lower edge of the condyle. A narrow fractured surface (fig. 4, *o*), the continuation of which was evidently directed inwards (*i. e.* presented to the observer), is seen on the side of the lower edge, stretching from the anterior boundary of the dentary foramen (*n*) on to the condyle. The rest of this inflected margin (what remains of it) is seen imbedded in the opposite slab (fig. 1, *b*, *o'*). It forms a lamina of great tenuity. The base of its inner bounding ridge shows a triangular fracture immediately under the orifice of the dental canal (at *n*, fig. 4), where it is comparatively thick: thence the section becomes gradually attenuated on to the condyle. There can be little doubt that this is the characteristic marsupial inflected angle, although feebly developed. It may have formed a slender elongated apophysis, with little inward inflexion, as in *Acrobata.*

The characters of the anterior portion of the inner side of the horizontal ramus, which are concealed by the contact with the matrix in the fragment fig. 1, *a, b,* are beautifully shown by a detached piece lately received from Mr. Beckles, represented by figs. 11–13. It comprises the anterior third of the ramus, the fracture having passed vertically through the middle of the last premolar. The incisor is broken off near the base of the exserted portion; the two anterior premolars are quite entire, and show well the diagonal grooving on both sides. The alveolar sheath of the incisor is entire all round, and its upper edge presents an exceedingly abbreviated diasteme. The symphysial portion is very short, directed upwards, massive, and obtuse. The disc of the harmonia or junction between the two mandibular pieces is distinctly defined (fig. 12, *b*). It is of comparatively small antero-posterior extent, of a broad elliptical or somewhat reniform outline, with the sinus directed backwards, and the long axis of the disc with but slight deviation from the vertical. The surface is perfectly smooth and without indentation, as is commonly seen in *Hypsiprymnus* and other herbivorous marsupials; while in the carnivorous and insectivorous genera of the same subclass, the symphysial harmonia is narrower and more elongated, with more or less inequality of surface for the reciprocal firm apposition of the united pieces. It is of some importance to take due notice of this character, however trivial it may appear, as every point is of value that can assist us in determining the affinities of this remarkable fossil genus. On the outer surface of this fragment the mentary foramen (fig. 11, *c*) is seen under the middle of the diasteme. It is round, well defined, and of good size. This instructive fragment furnishes direct evidence upon another point of importance, namely that there was but one large incisor on either side of the lower jaw.

It would have been of great interest and importance to have ascertained the character of the outer surface of the ascending ramus in *Plag. Becklesii*; that is to say, whether, in harmony with the marsupial indications as here interpreted, it presents a depression bounded by a raised ridge sweeping round on the lower side from the condyle to join on with a corresponding ridge descending along the anterior margin of the coronoid; and whether the depression terminated in a trumpet-shaped excavation of the horizontal ramus, common to it and the dentary canal, as occurs in *Hypsiprymnus.* But the fossil is so fragile, that I have not attempted to detach it for fear of injuring what it now exhibits. We may expect, however, if the excavations are continued at Purbeck with the same zeal with which they have hitherto been conducted, that abundant materials will be acquired for clearing up this single unascertained point connected with the characters of the lower jaw of *Plag. Becklesii.* From the direction which the fracture has invariably taken along the line of least resistance, in two fragments on reversed slabs, whenever a complete jaw has been discovered, and from the circumstance that the inner surface has been always exposed, and the outer remained in adhesion with the matrix, I am led to surmise that this has been caused by the matrix forming a plug in the excavation here referred to, thus causing it to adhere firmly; and I am prepared to expect that the outer surface of the ascending ramus will be found to agree in a great measure with that of the recent *Hypsiprymnus.*

[P.S. Since the preceding remarks were written, a fifth specimen of *Plagiaulax* has been discovered by Mr. Beckles, which supplies the desired information regarding the characters of the outer surface of the ascending ramus. See fig. 14, p. 280. It consists of the left ramus, nearly entire from the incisor to the condyle, showing the whole of the outer surface exposed. The specimen would seem to have belonged to a young individual of *Pl. Becklesii.*

The incisor is vertically inserted, and projects above the level of the premolars, of which there are three. The true molars, if present, are concealed behind the flap formed by the anterior margin of the coronoid process. This part of the jaw has been slightly crushed. The coronoid process rises more vertically, and is narrower than in the specimen, fig. 4; but a portion of the posterior margin is probably wanting. The base of the coronoid is occupied by a deep depression bounded on the lower side by a raised ridge, which sweeps round from the inferior part of the condyle, to be continued into the anterior margin of the coronoid process. The characters are clearly marsupial; but it is not determinable whether the depression terminates in an excavation of the ramus common to it and the dentary canal, as occurs in *Hypsiprymnus.* So far as can be seen, the depression would seem to be more limited. The matrix has been cleared away from the posterior inner margin, and a portion of the inflected angle is distinctly visible. The specimen, magnified four times linear, is represented by fig. 14. It bears out in every respect the marsupial inferences deduced from the other specimens; and indicates for *Plagiaulax* a position between *Hypsiprymnus* and the Phalangers.—June 20, 1857. H. F.]

The lower jaw of the other species, *Plagiaulax minor*, is represented by fig. 15, *a*, *b*, magnified 4 diameters, being double the scale of *Plag. Becklesii*, figs. 1 & 4. The outer side is exposed, the inner being adherent to the matrix. The notable points are—the shortness of the horizontal ramus from the offset of the coronoid to the border of the incisive alveolus, its great relative height on a line with the premolars (*p m*), and the bold curve of the lower margin. The incisor (*a*) is projected with a less sudden curve upwards, and its sheath is longer than in *Pl. Becklesii.* The premolars are also larger in proportion to the height of the jaw than in that species. Unluckily the whole of the ascending ramus is wanting, and with it are lost the significant characters yielded by the form of the condyle, coronoid process, and posterior angle. At the fractured posterior end (*b*), a small portion remains of the external oblique ridge which rises into the anterior border of the coronoid. A well marked wide depression is seen on the posterior part of the horizontal ramus under the true molars, corresponding with that shown on the jaw of *Plagiaulax Becklesii*. In the great development of the premolars, and the dwarfed size of the true molars, there is in the fossil an analogy with *Acrobata pygmæa*, the "Opossum-mouse," or "Pigmy Flying Opossum" of New South Wales. But the resemblance goes no further, the principal premolars in *Acrobata* being much elevated and pointed in front, leaning to the insectivorous type*, while they are uniformly compressed, grooved, and serrated in *Plagiaulax minor*.

This concludes what I have to offer in the shape of descriptive details. I shall now proceed to consider what may be legitimately inferred from them respecting the nature and affinities of the fossils. That the genus was mammal admits of no question: that it was a marsupial is inferred for the following reasons, which are given in the order of the directness of the indications:—

1. The compressed hatchet-shaped last premolar with the serrulated edge and parallel grooving. These characters are confined, among all known mammals, to the marsupial genus *Hypsiprymnus*; the correspondence in grooving is so exact that the number of furrows is the same in the fossils and in the recent species with which they were compared, namely seven; the difference, that they are diagonal in the former and vertical in the latter, being trivial and not typical.
2. The agreement in form, relative size, and direction of the solitary incisor in the fossil rami, with that of the recent *Hypsiprymni*.
3. The indication of the raised and inflected fold of the posterior inner and lower margin of the ramus.
4. The form and characters of the symphysial suture.
5. The absence of any character in the jaw or teeth inconsistent with the marsupial indications.

The presence of only two true molars might seem, at first sight, at variance with a marsupial determination, since it has been asserted, by an able authority, that, with the exception of the edentate "species of marsupials, or those which are nearly edentate, like the *Tarsipes*, and also excepting the *Myrmecobius*, all *Marsupialia* possess four true molars†." But the character is not absolute, for all the Pigmy-Phalangers of the subgenus *Dromicia*, besides *Acrobata*, are admitted to have only three true molars ‡. In the Purbeck fossils the premolars are inordinately developed, while the true molars are dwarfed and rudimentary in proportion. Where such characters coexist with an exceedingly abbreviated alveolar border, there is less reason for surprise in seeing two of the molars

* Waterhouse, Nat. Hist. of Mammalia, vol. i. p. 338.

† Waterhouse, Nat. Hist. of Mammalia, vol. i. p. 8. This generalization was previously stated by Professor Owen, in his memoir in the Zoological Transactions, vol. ii. p. 333, of the 8th Jan. 1839.

‡ Waterhouse, *op. cit.* pp. 307, 337.

suppressed. It is now well known, that there is no certain distinctive character, whether of placental or marsupial, that can be founded on the number of their teeth. Among the marsupials, *Myrmecobius* presents a case in which they are in excess; while the Purbeck *Plagiaulax* would seem to present the opposite condition, where they are below the normal number, from suppression.

The same reasons are equally strong for referring *Plagiaulax* to the neighbourhood of the existing genus *Hypsiprymnus*. The affinity indicated by the premolars and incisor is so manifest and direct, that details upon the differences from other terms of comparison, placental or marsupial, would be superfluous. The large grooved premolar is confined among the *Marsupialia* to *Hypsiprymnus*; that genus, comprising three subgenera, includes about ten species, in all of which the premolar is solitary, the true molars being constantly four. In *Plagiaulax* there are either three or four grooved premolars, and only two true molars. In *Acrobata* and some of the Phalangers, the inferior premolars are as many as four, the true molars in these instances being reduced to three, a dentary formula which closely approximates that of *Plagiaulax*; while in other Phalangers the premolars are single, the true molars attaining the full complement of four.

In regard to the indications of the true molars, which might, *à priori*, have been expected to be the most significant, the tritubercular antepenultimate, and the longitudinally two-edged last tooth are without a known analogue among living forms. They certainly bear no resemblance to any insectivorous species, placental or marsupial. The general form of the tubercles of the antepenultimate suggests some resemblance to the omnivorous pachyderms, but it is not sufficiently pronounced to counterbalance the strong leaning of the premolars to a herbivorous regimen. The wear of the two true molars would seem to indicate a grinding, as contradistinguished from a crushing or cutting action of the teeth; and this is confirmed by the form of the articulating surface of the condyle.

The characters of the jaw are so peculiar, and in some respects of so mixed and complex a nature, that they require to be weighed with caution, in conjunction with teeth, in forming any opinion regarding the affinities of *Plagiaulax*. The low position of the condyle is so pronounced, and the elevation of the coronoid above it so considerable, that regarded *per se*, supposing no teeth had been discovered, they might have been considered to imply with some degree of certainty, a predaceous animal. The condyle is even relatively lower in *Plag. Becklesii* than in *Thylacinus*, *Dasyurus*, and *Didelphys*, the most carnivorous among marsupial forms. A condyle so placed was considered by Cuvier to be a positive indicator of the ferine type. But in *Plag. Becklesii*, the force of the indication is counterbalanced by another character, of which, so far as I am aware, there is no example among any of the predaceous genera, either placental or marsupial, recent or fossil, namely the long neck and horizontal projection of the condyle behind the coronoid, the term "neck" being used for convenience to imply the constricted portion of the ramus between the bottom of the sigmoid notch and the lower margin. In all the ferine animals, the pivot of motion or transverse condyle is, for obvious mechanical reasons connected with the functions of the jaw, brought on a short stem close under the base of the coronoid process. In *Plagiaulax* it is carried out upon a long pedicle behind, and, *pro tanto*, there is a great deviation from the predaceous type. The arrangement is equally without a parallel among the herbivorous or omnivorous types, in which the condyle is ordinarily elevated above the horizontal plane of the teeth, with more or less freedom of lateral or longitudinal motion. Further, the convex articular surface of the condyle, and its vertical instead of transverse direction, are at variance with the locked implantation of the jaw of a ferine animal. The other leading indications all lean towards a vegetable feeder, namely, the limited surface and moderate elevation of the coronoid above the plane of the teeth; the feeble development of the inflected margin, and the absence of a thick angular process; the advanced position of the orifice of the dentary canal; the offset of the inflected margin above it, and the form of the symphysial suture. These characters, taken in conjunction with the marked signification of the teeth, would seem clearly to place *Plag. Becklesii* among the vegetable feeders. In this view, the exceptional position of the condyle would be regarded as a special modification, having reference to the abnormal character of the teeth, and the adjustment involved thereby; *i. e.* the excessive development of the premolars, and the suppression of so large a portion of the true molars, together with the functional degradation of the two which remain.

Giving due weight to these various considerations, and with the above-indicated analogy in the dental formula to guide us, I am led to the conclusion that *Plagiaulax* may be regarded in the natural system as a marsupial form of rodent, constituting a peculiar type of the family to which *Hypsiprymnus* belongs, and as bearing, in respect of number of teeth, the kind of relation to that genus which *Dromicia* bears to the other Phalangers, and *Acrobata* to *Petaurista*. Mr. Waterhouse includes the Kangaroo-rats among the *Macropodidæ*: *Plagiaulax* could never be classed among the Kangaroos. But, although inferred to have been allied to *Hypsiprymnus*, the fossils were generically widely distinct from the existing Kangaroo-rats. A great many links of the chain which would place them in connexion are unknown to us, some of which may yet turn up in the fossil state.

The species of *Plagiaulax* must have presented a form of which there is nothing to remind us among living marsupials. This is indicated by the extreme shortening, compression, and depth of the lower jaw, together with the sudden upward curve of the incisor, and still more by the depressed position and backward projection of the condyle. For aught that we know to the contrary, they may have had the volant habits of the Flying-Phalangers, and flitted from tree to tree among the oolite forests by means of parachute-folds of their skin. As the Kangaroo-rats are strictly herbivorous, gnawing scratched-up roots, it may be inferred of

Plagiaulax that the species were herbivorous or frugivorous. I can see nothing in the character of their teeth to indicate that they were either insectivorous or omnivorous.

The larger species, *Pl. Becklesii*, I have named after Mr. Beckles, the discoverer, to whose energetic and well-considered explorations Palæontology is indebted for so many and important additions to the Upper Oolite (Purbeck) fauna, after the efforts of the Geological Survey Department, specially directed to the same object, under so able a head as the late Professor E. Forbes, had proved unsuccessful. This species equalled the size of a squirrel, or nearly that of *Petaurus macrourus**, one of the Flying-Phalangers. The other species was very much smaller; and, being one-half the linear dimensions, was probably about one-twelfth of the bulk of the former, or near the size of the "Pigmy Flying Opossum," *Acrobata pygmæa*.

About the mammalian associates of *Plagiaulax* I abstain from making any remarks beyond the few which are introductory to this paper, as the fossils will so soon pass, for a detailed description, into the hands of Professor Owen, who has already designated one of the largest of the new forms by the generic name of *Triconodon*. The Purbeck mammalian genera announced up to the present date are therefore *Spalacotherium*, *Triconodon*, and *Plagiaulax*.

There are, however, some points of general geological interest, on which I may be permitted to make a few observations.

The first is the relation of resemblance which the molar teeth of *Plagiaulax minor* bear to those of the Triassic *Microlestes antiquus* of Plieninger. The agreement in general form is so close, that, had detached molars of both been met with in beds of the same formation, they might have been taken for back and front, or upper and lower teeth of the same, or of nearly allied, species. The essential crown-characters are the same in both, namely, two opposed longitudinal marginal ridges, more or less lobed or crenated, and separated by an intermediate chasm or depressed disc†. A solution, however approximative, of so ancient and obscure a mammal as *Microlestes* is not devoid of interest. Plieninger considered it to be predaceous, hence the name; other naturalists were disposed to regard it as leaning, however remotely, to the omnivorous Pachyderms, or omnivorous Insectivora; while Professor Owen, in recognizing at once the mammalian character of the teeth, admitted them to be distinct from

* The skeleton so named in the Cat. (Osteol. Mus.) Roy. Coll. Surgs., No. 1849.

† Judging from the very careful drawings and casts, the two teeth of *Microlestes*, figured in Lyell's 'Manual of Geology,' would appear, as there surmised, to indicate at least distinct species. The larger tooth (fig. 442. p. 343 of that work) resembles the penultimate molar of *Plagiaulax Becklesii*, regarded in the side-aspect, inner surface. There is in both an anterior talon, forming an accessory lobule where it joins on with the anterior inner tubercle. But I can detect nothing in either like the basal cingulum referred to by Mr. Waterhouse (*loc. cit.*). Fig. 441, representing the first-discovered tooth of *Microlestes antiquus*, crown-aspect, is the one which bears the closest resemblance to the last true molar of *Plagiaulax minor*.

anything fossil or recent known to him*. Pictet, in his 'Paléontologie,' doubtingly includes *Microlestes* among marsupials, for reasons which he does not state, upon the authority of some of the German describers, whose memoirs I have not been able to consult. Bronn notices *Microlestes*, in the 'Lethæa Geognostica,' as being probably a predaceous marsupial (3rd edit. vol. ii. p. 122).

The next point to which I would solicit attention is, that *Plagiaulax* would seem in some respects to furnish a crucial test of the soundness of certain generalizations which have been put forward regarding the order of successive appearance of mammalia upon the surface of the earth. It has been maintained by British palæontologists and comparative physiologists† of the highest authority, that, while there is no good proof of a serial progressive development from the lower to the higher forms, there is evidence of another order of development or successive passage, namely from the *general* to the *special*, as we descend from the oldest to the modern period. It is urged by the advocates of this doctrine, that the Mammalia of the Eocene period assimilated more to the general plan of the archetype and to the embryonic condition of the vertebrate organization; while the Mammalia of modern times successively furnish more and more numerous examples of deviation from the archetype, all tending towards special adaptation. Among other arguments, they insist that the earliest Eocene Mammalia, both carnivorous and herbivorous, possessed, in most cases, the full complement of teeth; while forms characteristic of later times, such as the *Felidæ* and *Ruminantia*, are remarkable for special suppression of these organs. If the generalization were really of as wide an application as has been claimed for it, we ought to find evidence of closer adherence to the general archetypic model the further back we recede in time. But so far is *Plagiaulax*, at present the oldest well-ascertained herbivorous mammal yet discovered, from giving any countenance to the doctrine, that it actually presents the most specialized exception, so to speak, from the rule to be met with in the whole range of the Marsupialia, fossil or recent. It had the smallest number of true molars of any known genus in that subclass, six at least of the normal number of incisors being also suppressed; thus exhibiting, at the most remote end of the chain, the very characters which, under the generalization in question, we might *à priori* have expected to encounter at the near end, among existing marsupials.

* Cited in Lyell's Manual, 5th edition, p. 343.

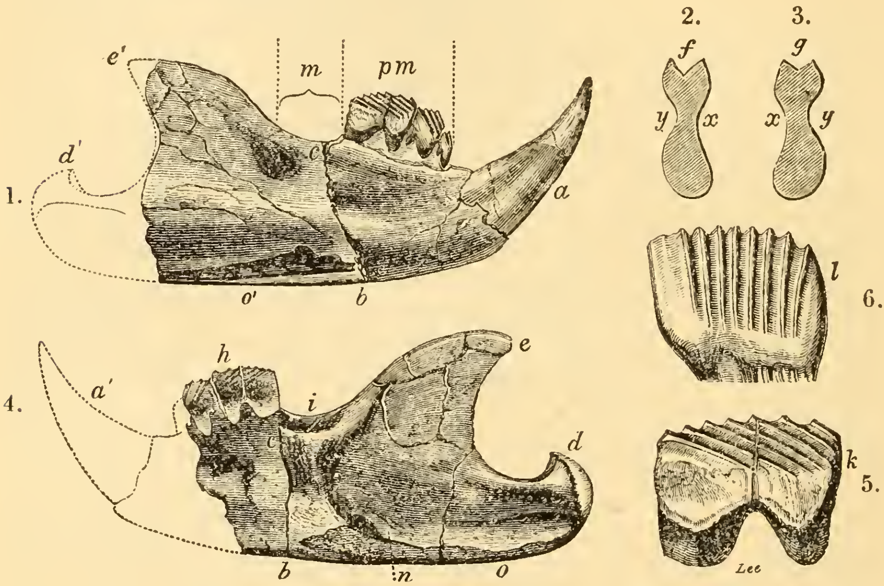
† Carpenter, Principles of Compar. Physiology, 4th edit. 1854, pp. 107–111. The doctrine here referred to is developed in considerable detail by Dr. Carpenter in the passage above indicated. In a note (*loc. cit.* p. 111) he disclaims it as having originated with himself: "The principle expounded in this paragraph has been prominently enunciated and illustrated by Professor Owen in various parts of his writings. The remarkable facts here stated with respect to the dentition of mammalia are contained in his article 'Teeth' in the Cyclopædia of Anatomy and Physiology, vol. iv." Some interesting illustrations bearing upon the retention of the typical formula of dentition in the placental mammals of the Eocene and Miocene periods, and upon the departure from it in modern mammals, are adduced by Professor Owen in his memoir 'On the Dentition of Phacochœrus,' Phil. Trans. for 1850, p. 495.—H. F., June 20th.

The curious fact, that only lower jaws should have turned up among the Stonesfield mammalian remains, has often been the subject of speculation or remark. The same, to a certain extent, has held good with the remains found in the Purbeck beds. Among the determined fossils, lower jaws predominate largely. But some upper maxillaries have been met with, and, while writing, I have received intimation of the discovery of more. Among the undetermined remains there is a considerable number of other bones of small animals, many of them probably mammals, but they are seldom or ever perfect. In these minute creatures, unless the bone be complete, and, supposing it to be a long bone, with both its articular surfaces perfect, it is almost hopeless, or at any rate very discouraging, to attempt to make out the creature which yielded it; whereas the smallest fragment of a jaw with a minute tooth in it, speaks volumes of evidence at the first glance. This I believe to be one great reason why we hear so much of jaw-remains, and so little of the other bones. For, as an inferior maxillary is to the other bones of the skeleton in the ratio of about 1 to 250, *cæteris paribus*, a large number of these should be encountered for every lower jaw that turns up. No indication has yet been met with at Purbeck of the bone of a good-sized terrestrial mammal. But I do not consider the negative evidence in this case to be decisive of their non-existence. The matrix of the so-called "Dirt-bed No. 93," by which most of the mammal remains have been yielded, is a whitish-grey, fine-grained marl, full of the exuviæ of freshwater animals, hardening into a kind of stone when the moisture is expelled by desiccation, but very bibulous, and readily becoming pasty, after immersion in water. It has properly no claim to the designation of a "dirt-bed," or "ancient vegetable soil," as there is rarely a speck of vegetable matter to be seen in the numerous specimens containing bone-remains which have passed through my hands*. It appears to me to present more the character of the deposit near the margin of a patch of fresh water, and that the probable explanation of the association of so many small bones of minute mammals and lizards is that they were the floating objects most readily drifted to the margin by a surface-ripple from wind, or by a wave-eddy. In India, in the tanks, or wherever running water falls into an artificial lake, numerous remains may be observed along the margin, of the bones of frogs, lizards, mice, and musk-rats, forming a more or less continuous edging, without the admixture of large bones, which lie in abundance below the deeper water. The former float and are drifted to the margin by the action of the wind, and rest there.

M. Lartet pointed out to me, in the rich Falunian deposit of Seissan, certain parts of the lacustrine bed where skeletons of large terrestrial animals, such as Mastodon and Rhinoceros, are more or less abundant; while in other situations near the margin immense

* I am informed by the Assistant-Secretary, however, that the hand-specimens of this bed, in which *Spalacotherium* occurred in 1854, were of a dark colour and contained vegetable remains, together with freshwater shells. See Quart. Journ. Geol. Soc. vol. x. p. 423.

Figs. 1–6. *Plagiaulax Becklesii* (figs. 1–5), *and Hypsiprymnus Gaimardi* (fig. 6). Figs. 1 & 4 *show the entire right ramus of the Lower Jaw, in two pieces, on reversed slabs of the same piece of matrix.* (Magnified two diameters.)



[Figs. 1 & 4 represent the same right ramus of the lower jaw seen on the opposite surfaces of a split stone, the two taken together affording data for a complete restoration of the jaw.]

Fig. 1. *a*, *b*, *e'*. Outer side of the anterior portion of the right ramus of lower jaw; magnified two diameters. *a*, *b*, outer side. *b*, *o'*, *d' e'*, impression of inner side.

a. Incisor.
b, *c*. Line of vertical fracture behind the premolars.
d'. Impression in the matrix of the condyle.
e'. Impression of top of coronoid process.
o'. Broken-off inflected fold of inner margin buried in the matrix.
m. Place of the two molars.
pm. Three premolars, the third or last divided by a crack.

Fig. 2. *f*. Section of the anterior piece of the jaw at the fracture *b*, *c*; *x*, inner surface; *y*, outer. The notch at the top is formed by one of the sockets of the double-fanged true molar.

Fig. 3. *g*. Section of the hinder piece near *b*, *c*; *x*, inner surface; *y*, outer surface.

Fig. 4. *a'*, *d*. Inner side of the posterior portion of the same lower jaw on the opposite slab of stone; *b*, *d*, *e*, inner side; *b*, *a'*, *h*, cast and impression of outer side.

a'. Outline of the incisor restored.
b, *c*. Line of vertical fracture.
d. Condyle.
e. Coronoid process*.
h. Impression of the three premolars on the matrix.
i. Empty sockets of the two true molars.
n. Orifice of dentary canal.
o. Indication of the raised and inflected fold of the posterior inner margin.

Fig. 5. *k*. Third or largest premolar, showing the seven diagonal grooves; magnified 5½ diameters.

Fig. 6. *l*. Corresponding premolar in the recent Australian *Hypsiprymnus Gaimardi*, showing the seven vertical grooves; magnified 3½ diameters.

[These illustrations have been obligingly lent by John Murray, Esq., F.G.S.]

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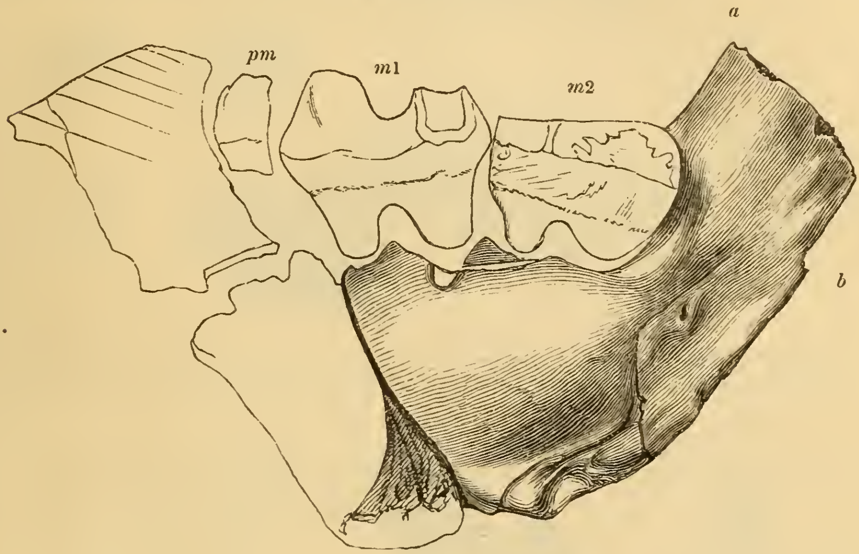
* The artist has made the point of the coronoid (*e*) project too much backwards, and the curve of the posterior margin too great; the line being nearly vertical in the original. The projection of the condyle behind the coronoid margin is more considerable than is shown by the figure, and the neck longer.

Figs. 7, 8, 9, & 10.—*Plagiaulax Becklesii. Portion of the right ramus of a lower jaw, and different views of the two true molars.*

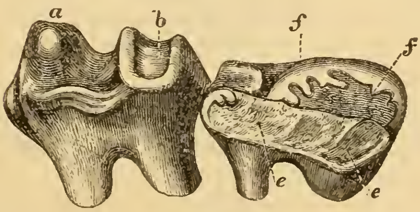
(Fig. 7. A portion of the jaw, with two molars *in situ*, magnified 10 diameters; fig. 8, inner side of the molars, magnified 10 diameters; fig. 9, outer side, 7 diameters; fig. 10, summits of the crowns of the molars, 7 diameters.)



7.

Fig. 7. *a*. Anterior margin of the coronoid process.
b. Fractured posterior margin.
pm. Impression of the last premolar,
*m*1. First true molar.
*m*2. Second true molar.

8.



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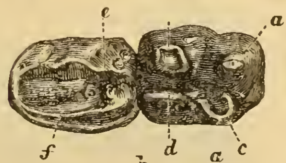

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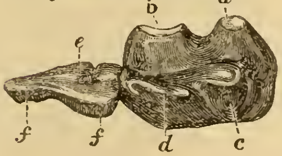
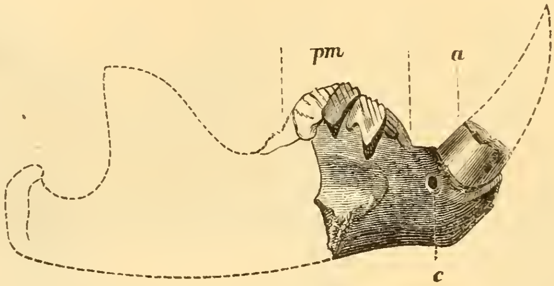


Figs. 8, 9, & 10.
- *a*. Anterior inner point of penultimate molar.
- *b*. Posterior inner point of the same molar, showing the disc of wear.
- *c*. Anterior outer point.
- *d*. Posterior outer edge.
- *e e*. Fractured surface of interior edge of the last molar.
- *f f*. Ground surface of outer edge of the same.

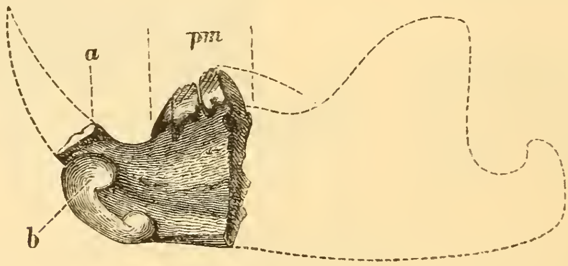
Figs. 11, 12, & 13.—*Plagiaulax Becklesii. Fragment consisting of the anterior portion of the right ramus of the lower jaw.* Magnified 2 diameters.

Fig. 11. Outer surface.
Fig. 12. Inner surface.
Fig. 13. Vertical view, seen from above.



11.

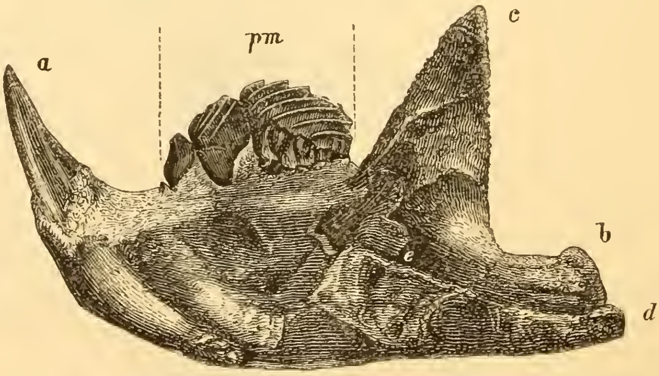
13.



12.

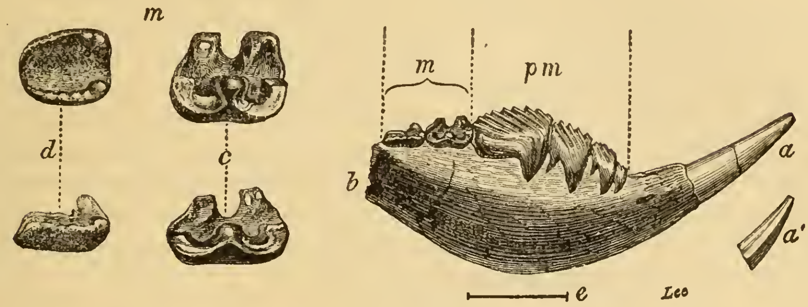
a. Incisor.
pm. Premolars.
b. Symphysial harmonia.
c. Mentary foramen.

Fig. 14.—*Plagiaulax Becklesii. The left ramus of the lower jaw, nearly perfect, showing the outer surface.* Magnified 4 diameters.



a. Incisor.
b. Condyle.
c. Coronoid process (broken at the edges.)
d. Inferior boundary ridge.
e. Depression on the base of the coronoid.

Fig. 15.—*Plagiaulax minor. Outside of the right ramus of the lower jaw; and the two molars.* Magnified.



[All the teeth in this specimen are in place and well preserved. The hinder part of the jaw-bone, with the ascending ramus and posterior angle, are broken away.]

a, b. Right ramus of lower jaw, with all the teeth; magnified 4 diameters.
a. Incisor with point broken off. *a′*, impression of same, showing that the inner side near the apex was hollowed out in a longitudinal direction.
b. Offset of coronoid, the rest of which is wanting.
m, m. The two true molars.
pm. The four premolars.
c. The first molar; magnified 8 diameters. Upper figure, the crown. Lower figure, side-view.
d. Second molar; the crown and side-view.
e. The length of the jaw, natural size.

[Woodcut fig. 15 has been kindly lent by John Murray, Esq., F.G.S.]

Figs. 16 & 17.—*Teeth of Microlestes antiquus of Plieninger, from the Upper Trias of Wirtemberg.* Magnified.

16.

17.

Fig. 16. *b.* Crown of the smaller molar *.
Fig. 17. *c.* Crown of larger tooth †, with part of the crown broken off.

[The cuts, figs. 16 & 17, have been kindly lent by John Murray, Esq., F.G.S.]

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* See Lyell's Manual Elem. of Geol. 5th edit. fig. 441, *b*, p. 343.
† *Ibid.* fig. 442.

quantities occur of the bones of small animals, such as frogs, lizards, shrews, and minute rodents, which may be taken up by the handful unmixed with larger bones. The mammaliferous band "No. 93," where most productive, does not exceed 5 inches in thickness. If the excavations could be carried into a line of section where the bed is thicker, it does not seem too much to hope that they might be rewarded by the discovery of larger mammals, when we consider the numerous acquisitions to Palæontology which have been made within the last two months alone from Purbeck, and the improbability that a fauna already proved to have been so extensive, should have been restricted to small creatures only. Further, where herbivorous mammals are shown to have existed, it would seem in the highest degree improbable that they should have been limited to a single genus containing two small species like *Plagiaulax*.

March 25, 1857.

The Rev. John Montague and William Sowerby, Esq., were elected Fellows.

The following communications were read :—

1. Palichthyologic Notes. No. 9. *On some* Fish-remains *from the neighbourhood of* Ludlow. By Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S.

[Plates IX. and X.]

At the request of Sir Roderick Murchison I have undertaken the examination of some specimens of Fossil Fishes, discovered by Mr. Salwey and Mr. Lightbody—by the former in the Old Red Sandstone of Acton Beauchamp, and by the latter in the Upper Bonebeds in the neighbourhood of Ludlow. I have performed this task with some reluctance, in consequence of the scanty number and defective condition of the specimens submitted to examination, being strongly impressed with the inconvenience which results from the attempt to define genera and species upon insufficient data, the characters so expressed being liable hereafter to alteration or modification, as our knowledge of the subject becomes enlarged by the discovery of more perfect materials.

It is no less fortunate than singular that, concomitant with the earliest discovery of Cephalaspid remains in England, the contemporaneous beds in Scotland should have furnished the clue to their true character; it is still more singular, but less fortunate, that, although so many years have elapsed since Professor Agassiz first recognized their Ichthyic affinities, and although so many zealous and talented explorers have since been ransacking the English localities, so far as I am aware, not one single specimen has been brought to light which would have enabled even that distinguished naturalist to pronounce a positive opinion as to its place in the scale of nature.

The genus *Cephalaspis* is typified by the Scotch species named, after Sir Charles Lyell, *Cephalaspis Lyellii*. This species, as recognized by the cephalic buckler, is of frequent occurrence in the English beds; and is associated with other forms, not found in the Scotch beds, differing considerably in general character, but agreeing to a certain extent in structural details. Professor Agassiz refers these to the same genus with hesitation and reservation, for, having described them as *Cephalaspis Lewisii* and *C. Lloydii*, he says*, "It appears to me probable that some day, when better known, these two species should be separated generically from *Cephalaspis Lyellii*." Following out this suggestion, Dr. R. Kner has proposed for these and some allied forms the generic title *Pteraspis*, a name which has been accepted and adopted by Professor Huxley and Mr. Salter, in describing some new species discovered by Mr. Banks in the neighbourhood of Kington†.

The materials submitted to me for examination are scanty, and afford little scope for detailed descriptions; at the same time they exhibit new characters of sufficient importance to merit notice.

Cephalaspis Salweyi, spec. nov. Pl. X. fig. 1.

I will first speak of the specimen found by Mr. Salwey, of Acton Beauchamp. It exhibits the central and greater portion of a cephalic buckler of a large species of *Cephalaspis*. The peripheral parts are wanting, as are also the posterior angles of the buckler, leaving it doubtful whether or not the latter were extended to form the sharp spurs so remarkable in *Cephalaspis Lyellii*. The length of the shield from the snout to the posterior angle of the occipital crest is $3\frac{1}{4}$ inches; the breadth from the median line between the orbits to the margin of the shield $1\frac{1}{10}$ inch, which gives $2\frac{2}{10}$ inches for the entire breadth. The space between the orbits is $\frac{1}{2}$ an inch, and the transverse diameter of the orbit $\frac{3}{10}$ of an inch. From the snout to a point on the median line between the orbits is $1\frac{2}{10}$ inch, and from the same point to the termination of the occipital crest is 2 inches. On comparing these measurements with the corresponding dimensions of a specimen of *Cephalaspis Lyellii* of the same comparative size, it will be seen that the buckler of this species is more elongated, the orbits more distant from each other, and their position more advanced. It may be said, and perhaps with justice, that Mr. Salwey's specimen, from its imperfect condition, does not afford a fair standard of comparison, and that it may only be a portion of a large individual of the known species. I have already stated that the peripheral parts are wanting, and therefore I do not insist on the measurements in which they are implicated. There is, however, a constant character on which to rely in the size and relative position

* Poissons Fossiles, ii. p. 152.

† Quart. Journ. Geol. Soc. vol. xii. p. 93.

of the orbits. The diameter of each eye-socket in *Cephalaspis Lyellii*, as compared to the interspace between them, is as one to one, whereas in the new species it is as three to five, and this without any dislocation or fracture, on comparison of the specimens compared, by which to account for so great a discrepancy. Some doubt has hitherto been entertained as to the true homology of the orifices which I have considered as the orbital depressions, in consequence of the absence of these features in *Cephalaspis* (*Pteraspis*) *Lewisii* and *Lloydii*. Mr. Salwey's specimen resolves this doubt satisfactorily, for it exhibits unmistakeably the cast of the sclerotic coat of the eye-ball (Pl. X. fig. 1 *b*).

There remains another character to be mentioned corroborative of the specific distinction of Mr. Salwey's *Cephalaspis*. It is needless to occupy time with a description of the structure of the several bony laminæ of which the buckler is composed, which corresponds with that already published of the analogous parts in *C. Lyellii*. There is, however, a striking difference in the surface-ornament of the outer or dermal layer. This does not present a continuous stratum of enamel investing the subjacent bone, nor does it exhibit any of the parallel striations seen in other species of the genus; but the enamel occurs in small drops or splashes, scattered here and there irregularly over the surface, resembling somewhat the ornament in the head-bones of *Coccosteus*; the granules, however, being fewer in number and less regular in shape and disposition (Pl. X. fig. 1 *c*).

It is much to be desired that other specimens of this species may be brought to light, since much remains to be known as to the form of the shield, which I am inclined to think differed considerably from the regular crescentic outlines of *Cephalaspis Lyellii*. I have named this species *Cephalaspis Salweyi*, after its discoverer.

Cephalaspis Murchisoni, spec. nov. Pl. IX. fig. 1.

Two specimens collected by Mr. Lightbody in a bed below the Paper-mill on the Teme at Ludlow afford presumptive evidence of a new species of Cephalaspid, about the size of *Cephalaspis Lyellii*. One shows the concave inner surface of the cranial cavity, the other is a cast of the buckler of a smaller individual with some portions of the bone still adhering. The larger one, being the more perfect, is selected for description; but so far as the state of preservation of the specimens will admit of comparison, there is a perfect agreement between the two. The occipital crest is wanting; but, as the posterior margin of the buckler is preserved up to a point in close proximity to the crest, the comparative measurements will be taken from that point. From thence to the extremity of the snout the dimensions are 2 inches $\frac{4}{10}$ths. From a central point on the median line, between the orbits, to the snout, is 1 inch $\frac{3}{10}$ths; and from the same point to the hinder border of the shield, 1 inch $\frac{1}{10}$th. The diameter across the line of the orbits is 2 inches $\frac{7}{10}$ths. The interspace between the orbits is rather less than the diameter of the orbit. As several of these dimensions must necessarily vary, subject to the various degrees of compression and consequent expansion to which the buckler has been exposed, no great reliance can be placed upon them; but, on comparing them with a specimen of *Cephalaspis Lyellii*, as near as may be in the same condition of preservation, Mr. Lightbody's species very nearly resembled the typical species in the form of the anterior portion of the cephalic disk. The orbits, however, appear to have been relatively larger, more approximated, and more distant from the snout. The most striking feature in this *Cephalaspis* is the form of the hinder margin of the shield. In *Cephalaspis Lyellii* this margin advances forward from either side of the occipital crest to a considerable distance, and thence sweeps backwards to form the lateral armatures of the shield, like two high arches springing from a central pillar. The curvature of this border is so great that it would be indicated by a very small portion of this part of the shield. In the specimen under consideration nearly an inch of the border is preserved on either side the occipital region, apparently in its natural position, without any appreciable signs of accidental fracture or tension. The curvature of these portions is so slight, that, if produced to meet the periphery of the shield, the result would be that, in lieu of the sharp elongated spines so characteristic of *Cephalaspis Lyellii*, the posterior external angles would be short and blunt, and the general outline of buckler rather semicircular than crescentic. The posterior margin of the shield is strengthened by a thickening of the bone, forming a marginal rib similar to that described by the late Mr. Hugh Miller and myself in the carapace of the genus *Pterichthys*. The structure of the bones in this species is remarkably coarse and fibrous, and the vascular impressions are large and sinuous. The characters of the dermal integument are not disclosed in either of the specimens of this species, but the subjacent layer exhibits the curious polyhedral structure common to this genus and the allied *Pteraspides*.

One remarkable feature, as seen in the larger of Mr. Lightbody's species and having reference to the generic peculiarities of the *Cephalaspis*, remains to be noticed. In all the specimens of the genus I have hitherto examined, the eyes would seem to have been situated in foramina in the bony envelope of the cranial cavity; but there is evidence here to show that the base of the orbit was closed by a layer of bone, and that the eye-ball was lodged in a complete bony socket: Pl. IX. fig. 1.

It is much to be desired that some additional evidence may be obtained to complete the specific details of this interesting Cephalaspid; in the meantime, as I have little doubt of its specific discrepancy from *Cephalaspis Lyellii*, I should wish to dedicate this new member of the genus to the distinguished author of the 'Silurian System,' by the name of *Cephalaspis Murchisoni*.

The specimens next to be described are from dark micaceous shales in the cutting of the Hereford Railway at Ludlow.

Cephalaspis ornatus, spec. nov. Pl. IX. figs. 2, 3.

These reveal another species of Cephalaspid, well characterized by the ornament of the dermal covering of the shield. In this species the centres of the polygonal ossicles of the second stratum of the buckler are elevated into distinct umbones, and over these a thin dermal layer is spread, thickly covered by small granular asperities. From the combination of the two characters, a very ornamental design results, which can be recognized in a mere fragment of the shield (Pl. IX. fig. 3, *b*), and warrants the designation of *Cephalaspis ornatus*, which I propose for this species It differs in other respects from the species already described. The orbits are small and more distant from each other than they are in *Cephalaspis Murchisoni*. In the slight amount of curvature of the posterior margins of the shield, and in the thickening of the margin, it agrees with the corresponding parts of *Cephalaspis Murchisoni*. The dimensions are as follow:—from the snout to the posterior edge of the shield 1 inch and nine-tenths,—of this the anterior portion from the snout to a point on the median line between the orbits is eight-tenths, and from thence to the nape eleven-tenths. The exact width across the line of the orbits is not ascertainable: it probably corresponded pretty nearly with the length of the shield.

These specimens are from a more argillaceous stratum than those above described, and it is possible that its preservative properties may have protected delicate characters such as the skin-ornaments, which have perished in the more arenaceous beds from which the other specimens were collected. The other discrepancies are not so decided but that, should a better-preserved specimen of *Cephalaspis Murchisoni* reveal the dermal characters above alluded to, the specific name *ornatus* may be cancelled, and the characters here detailed be appended to the specific attributes of *Cephalaspis Murchisoni*.

Auchenaspis Salteri, gen. et spec. nov. Pl. IX. figs. 4 & 5.

The same argillaceous beds in the Ludlow railway-cutting from which the specimens last described were derived have furnished two other specimens of great interest. They are both tolerably perfect, and correspond so closely in every particular, that it matters little which is selected for description. What is written concerning one is corroborated by the other. I take then the first that presents itself, and I find a Cephalaspis in miniature, a pigmy not larger than a fourpenny-piece. The outline of the shield, the eye-sockets, and the nasal depressions, are all clearly defined. If size were a criterion of species, it would be undoubtedly a new one. Questions, however, of age and growth (of which we have as yet had no evidence in this group of extinct fishes) have to be duly considered before relative magnitude can be taken as a specific character.

On examining the specimen more closely, a new feature is observed. Behind the shield, and united to its posterior margin by a distinctly marked suture, is situated a broad plate divided into two lateral halves by a prolongation of the occipital crest (Pl. IX. figs. 4 & 5). These plates are nearly coincident in width with the diameter of the shield, and in length equal two-thirds of its antero-posterior dimensions. The evidence of the Scotch specimens of *Cephalaspis Lyellii* assures us that, in that, the type of the genus, the cephalic buckler was immediately succeeded by the scaly covering of the trunk, without the intervention of a nuchal plate. Such a deviation from the type is of too much importance to be considered a mere specific character; if substantiated, it implies generic distinction. At first I imagined it might be an embryonic character, an idea somewhat strengthened by the small size of the specimens. Should, however, the cranial shield of *Cephalaspis* have resulted from the coalescence of several plates arising from distinct centres of ossification, appreciable in the earlier stages of development, although subsequently obliterated, the structure of all the plates should be homogeneous. This is not the case: the coarse fibrous character is limited to the cranial shield, and the posterior plates seem to have been composed of a compact material, more analogous in structure to true dermal plates. The specimens leave it in doubt whether the post-cephalic plate was single or double. The occipital crest extends backwards nearly to the extremity of the nuchal plate, and in this the fibrous structure is evident, but there is no appearance of any inosculation between this material and that constituting the plates. It is therefore probable that this prolongation of the occipital region of the shield gave attachment to a pair of plates, one on either side, rather than that it constituted an integral portion of a single plate. In selecting a generic title for this interesting form, I am desirous of expressing the peculiar structure above described; I propose, therefore, to call the genus *Auchenaspis*.

Of the two specimens submitted to examination, one is rather distorted by pressure (fig. 5), the other retains its original figure (fig. 4). I select the latter, therefore, for those details which have reference to form. The outline of the shield anteriorly is nearly semicircular. From the base of the occipital crest to the snout, it measures 8 millimetres; of this the anterior portion from between the orbits to the snout measures 5 millimetres. The diameter across the base, a little in advance of the lateral posterior angles, is 12 millimetres, or nearly half an inch. Each nuchal plate is 5 millimetres in breadth at its junction with the shield, and about 4 millimetres in length. The posterior angles of the shield are short; they project outwards and backwards beyond the anterior margins of the nuchal plates. The posterior border of the shield on either side the occipital crest is but slightly curved; it has a thickened margin, slightly bevelled posteriorly, for the attachment of the nuchal plates. In these respects it closely resembles the corresponding parts of *Cephalaspis Murchisoni* and *C. ornatus*. The texture of the bone is exceedingly coarse, with the exception of the peripheral portion, which is finer in grain, and appears to have been invested with an outer layer of some thickness, forming a prominent border to the shield. None of these structures bear any evidence of immaturity. The nuchal plates are rather broader than long; in form they very much resemble the opercula of a *Leptolepis* or *Philodophorus*. The under surface is traversed by a series of vascular grooves, diverging outwards from the inner anterior angles. The substance of the plates is finely granular, and the exterior surface is characterized by minute transverse striations; whether the latter appearance is attributable to a thin exterior integument or not, can only be decided by microscopic examination; indeed, many of the details I have alluded to are so minute, that the aid of a pocket lens is not sufficient to enable me to offer them with any degree of certainty, and the specimens are too precious to be mutilated for more exact microscopical scrutiny. As Mr. Salter first directed my attention to the structural peculiarities these specimens present, I wish to name the species *Auchenaspis Salteri*.

It remains for time and industry to determine whether the species described above as *Cephalaspis Murchisoni* and *Cephalaspis ornatus* rightly belong to that genus, or whether they ought not to be referred to the genus *Auchenaspis*. The peculiar form of the hinder margin of the cephalic buckler, so different from that of the typical *Cephalaspides*, and yet corresponding with that of *Auchenaspis*, gives some substance to the idea that it may have reference to the attachment of nuchal plates; and if so, these species must necessarily be included in that genus. Much remains to be done with reference to the structural anatomy and true affinities of this curious family—subjects far beyond my grasp; but which I trust ere long will be grappled with and elucidated by Professor Huxley, who has already bestowed some time upon them, and than whom no one is better qualified for bringing the inquiry to a successful issue.

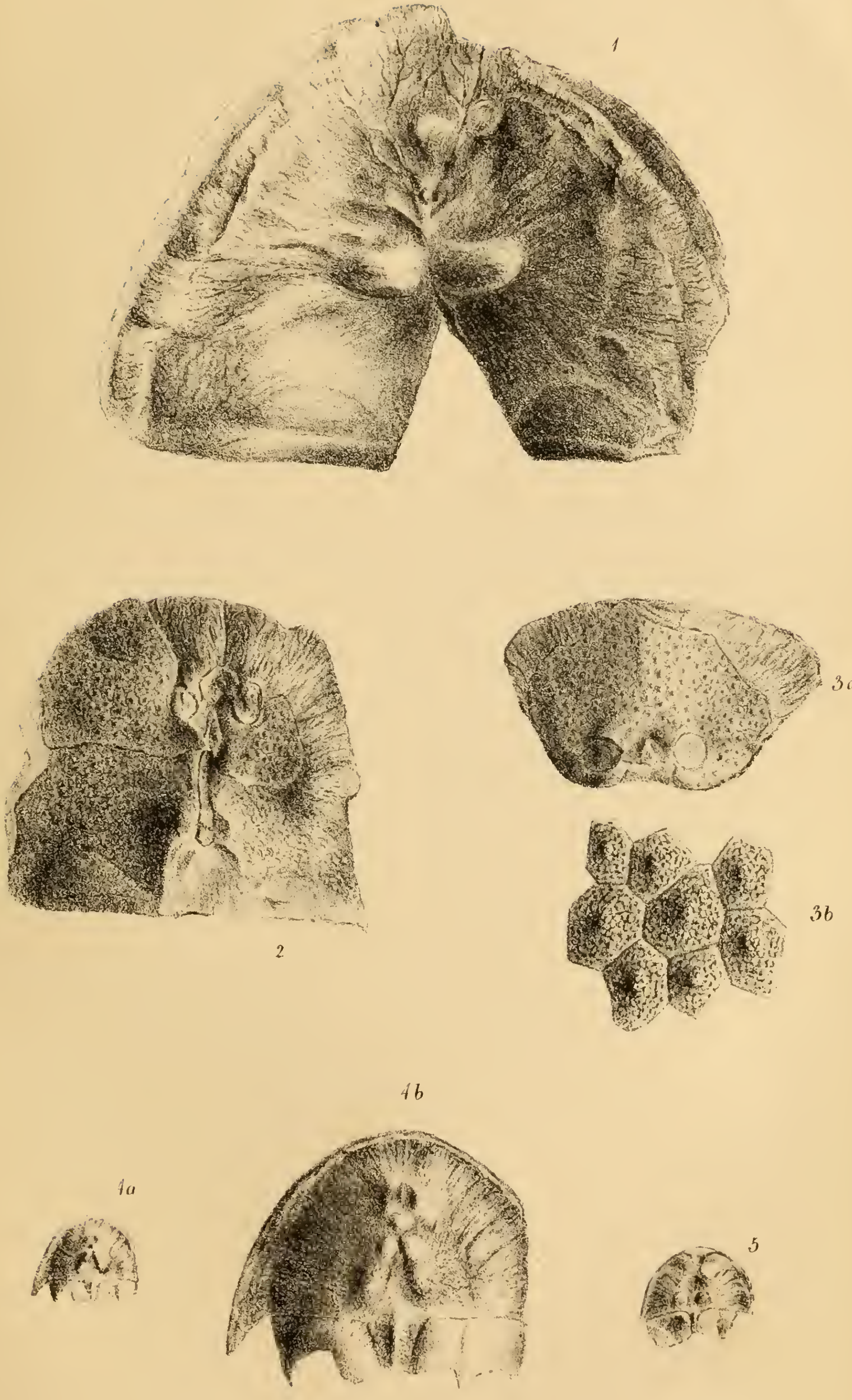
Associated with the specimens described above, both in the railway-cutting at Ludlow, and in the bed of the River Teme, Mr. Lightbody has discovered some other remains of fishes worthy of notice, although too fragmentary to be accurately characterized.

Of these, four specimens are portions of jaws corresponding generically with those described by Professor Agassiz under the name of *Plectrodus* and resembling the *Plectrodus mirabilis* rather than *P. pleiopristis* *. Although at first sight the large laniary teeth appear single, yet on closer examination the fractured surfaces are distinguishable whence the lateral denticles distinctive of the genus have been broken off. These teeth are grooved longitudinally, a character not well shown in the specimens figured in the 'Silurian System.' Fig. 4 is from the railroad, and figs. 2 & 3 from the fish-bed on the river.

The remaining specimens are Ichthyodorulites. One resembles *Onchus Murchisoni*. The longitudinal ribs (fig. 6) certainly appear coarser than those in the specimens of this species already figured; but this may be accounted for by the fact that the specimen only shows the dorsum of the ray, that portion in which the surface-character is always more strongly marked than on the lateral and posterior parts. This specimen is from the argillaceous beds in the railway-cutting at Ludlow.

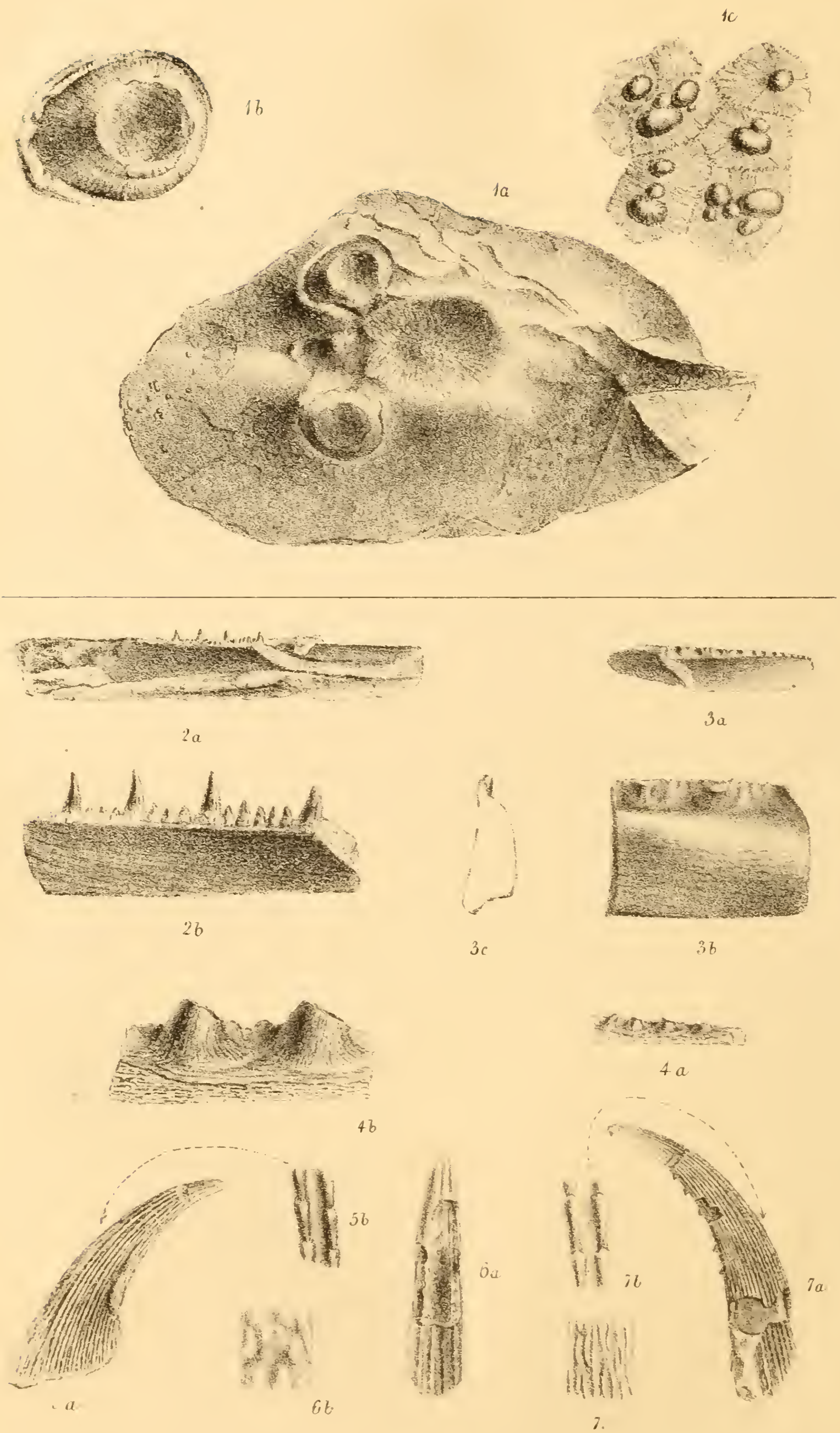
A second species from the same locality appears to be undescribed

* Sil. Syst. p. 606, pl. 4. figs. 14–17, 21, 25, 26, & figs. 18, 19, 22–24.



G. W. lith. W. West Imp.

CEPHALASPIS & AUCHENASPIS.
from the Passage-beds (Tilestones) near Ludlow.



FISH REMAINS
from the Old Red of Acton Beauchamp
& from the Tilestones near Ludlow

(fig. 7). It is about an inch and three-quarters in length, but is imperfect at the lower end. It is much curved, and the posterior edge is armed. Both these characters separate it from the genus *Onchus*, as now restricted*. The longitudinal ribs are fine and numerous, and show a tendency to tuberculation not found in *Onchus*. Near the base and in the neighbourhood of the posterior margin, the tubercles are distinct. The ribs, although continuous, are constricted at intervals, as in the genus *Ctenacanthus*. In many of these particulars this ray corresponds with the genus *Byssacanthus*; but it differs in being compressed rather than cylindrical. It has some resemblance to the posterior part of an *Erismacanthus* spine. A specimen (fig. 5) from the grit-bed opposite the Paper-Mill, in which *Cephalaspis Murchisoni* was found, much resembles the above. It is however shorter, more curved, and broader at the base. These characters are such as would attach to the spine of the second dorsal fin, and are not to be relied upon as specific differences, especially since in the more significant features there is a close approximation between the two specimens.

EXPLANATIONS OF PLATES IX. & X.

Pl. IX. fig. 1.	Cephalaspis Murchisoni; inside of carapace.	From opposite the Paper-Mill, near Ludlow.
2.	C. ornatus; outside of carapace.	From the Railway-cutting, near Ludlow.
3 *a*.	C. ornatus; anterior portion of carapace.	
3 *b*.	The same; portion of the surface-ornament, magnified.	
4 *a*.	Auchenaspis Salteri; carapace.	
4 *b*.	The same; magnified.	
5.	A. Salteri; another specimen.	
Pl. X. fig. 1 *a*.	Cephalaspis Salweyi; carapace.	From the Old Red Sandstone at Acton Beauchamp.
1 *b*.	The same; eye-capsule.	
1 *c*.	The same; portion of the surface-ornament, magnified.	
2 *a*.	Plectrodus; portion of jaw.	From opposite the Paper-Mill, near Ludlow.
2 *b*.	Part of the same, magnified.	
3 *a*.	Plectrodus; part of a jaw, with the impression of a larger portion.	
3 *b*.	The same; magnified.	
3 *c*.	The same, end-view, magnified.	
4 *a*.	Plectrodus, portion of jaw.	From the Railway-cutting, near Ludlow.
4 *b*.	Part of the same, magnified.	
5 *a*.	Ichthyodorulite.	From opposite the Paper-Mill.
5 *b*.	Rugosity of the ridges, magnified.	
6 *a*.	Onchus Murchisoni?; fragment.	From the Railway-cutting.
6 *b*.	Portion of the rugose interior surface, maguified.	
7 *a*.	Ichthyodorulite.	
7 *b*.	Rugosity of the ridges, magnified.	
7 *c*.	Cast of portion of the rugose interior surface, magnified.	

* Poissons du Vieux Grès Rouge, p. 117.

2. *Note on the Relative Position of the* STRATA, *near* LUDLOW, *containing the* ICHTHYOLITES *described by* Sir P. Egerton*. By Sir RODERICK MURCHISON, V.P.G.S.

THE localities near Ludlow which afforded the fossil fishes described by Sir P. Egerton were examined by me in July 1856, accompanied by Mr. Lightbody, Professor Ramsay, Mr. Salter, and Mr. Aveline; and the relations of the strata were briefly explained in a notice offered to the British Association at the Cheltenham Meeting. As the abstract of that communication, published in the 'Athenæum,' was somewhat inaccurate, and does not convey my matured opinion, I here first place on record the statement which I intend to publish in a second edition of my work 'Siluria.'

The section of the railway-cutting north of Ludlow exhibits an upcast by which some of the highest beds of the Ludlow Rock are brought up against Old Red Sandstone on the north-west. This small insulated mass is manifestly distinct from, and younger than the formerly described bone-bed of the Upper Ludlow Rock†. That stratum, as described in my work, is overlaid by the Downton-castle building-stone and other grey strata constituting the lower portion of the 'Tilestones,' whilst this band at the railway, in all about 6 feet thick, is at once conformably surmounted on the south-east by micaceous sandstone and red shale or marl. Though higher in the series, this thin band still contains some characteristic fossils of the lower course, such as the *Plectrodus*, sp., *Onchus Murchisoni*, Ag., and the *Lingula cornea*, Sow. On the other hand, the following species are unknown in any inferior stratum, viz. *Cephalaspis ornatus*, Egerton‡, *Auchenaspis Salteri*, Egerton§, *Onchus* or *Byssacanthus*, sp., together with *Pterygotus anglicus*, Ag., and *Eurypterus pygmæus*, Salter||. The two last-mentioned fossils, having been recognized by Mr. Salter, are about to be described in full in the Decades of the Survey.

The natural features on the right bank of the Teme, south of Ludlow, *i. e.* between Ludford and the Paper-Mill, offer a more satisfactory succession. They prove that the original bone-bed, sloping down to the south-east at a very gentle angle, is covered by strata representing the Downton-castle stone, the whole passing under brownish, micaceous thin-bedded, sandstones, which, to the east of the Corn-mill, are covered by red marl or shale, with minute green concretions or cornstones. These strata are so much obscured by drift and gravel, that the observer can detect the beds here and there only, where the water is very low. It is therefore probable that the thin fossiliferous band exposed at the railway, the intermediate range of which is hidden by detritus, may still be discovered on the banks or in the bed of the River Teme. However this may be, another and still higher fossil band was discovered by Mr. Lightbody, and this is the "grit-bed," the fossil fishes of which are also

* See above, p. 282.
† Sil. Syst. pp. 197, &c., and Siluria, pp. 137, &c.
‡ See above, p. 285.
§ See above, p. 286.
|| Quart. Journ. Geol. Soc. vol. xii. p. 99.

described by Sir P. Egerton*. It is a whitish-grey micaceous sandstone containing crustacean fragments and coprolites, as well as fishes, with several of the fossils before mentioned.

Seeing that the *Plectrodus mirabilis*?, *Onchus Murchisoni*?, and *Lingula cornea*, that characterize the lowest of these bone-beds, are still present in this higher stratum, I might naturally class this micaceous grey sandstone, though it be associated with some red and green marls, as the last link of the Silurian series of life. But the *Cephalaspis Murchisoni*, Egerton†, may be rather considered to indicate that this stratum marks a true passage upwards into the Old Red or Devonian System, while it constitutes the uppermost layer of the so-called "Tilestones."

The copious development of red marls, thick-bedded sandstones, and cornstones which follow, with the *Cephalaspis Lyellii*, *Pteraspis Lloydii*, &c., form the great overlying masses of Old Red Sandstone. In conclusion, I would remark, that the Tilestones of Shropshire and Herefordshire, which connect the Silurian and Devonian rocks, may, according to the predominance of certain fossils, be classed either with the inferior or the superior system. Their maximum thickness may be considered to be about 40 or 50 feet.

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3. *On the Occurrence of* Bones *of* Mastodon *in* Chile. By W. Bollaert, Esq., F.R.G.S., Corr. Mem. University of Chile, &c.

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

[Abridged.]

But few instances of the occurrence of fossil bones on the Western side of the Andes‡ have been recorded. During my late visit to South America, I made inquiries as to the existence of fossil bones in the Isthmus of Darien, but I could not learn that any had been met with, although railway-cuttings across the Isthmus were in progress§.

Old Spanish writers speak of "bones of giants" having been found at Manta, on the coast of the Pacific, 0° 59′ S., 80° 40′ W., and at Punta St. Elena in 2° 11′ south of the equator and also on the Pacific‖. Humboldt, from the information of others, states that these bones are remains of great cetacean animals.

South of this, in the desert plains of Tarapacá (19° to 22° S.),

* See above, pp. 284 & 288. † See above, p. 284.

‡ Two species of *Mastodon* have been discovered on the Eastern side of the Andes. The one (*Mastodon Andium*) has been met with in Peru, Chile, and Tarija; the other (*M. Humboldtii*) occurs in Buenos Ayres, Brazil, and Columbia; Cuvier's conjectural determination of these species was settled by Laurillard (*Dict. d'Hist. Nat.* Art. Mastodon) and confirmed by Gervais (*Voyage de Castelnau*).

§ A notice of some fossil shells from the Panama Railway is given in Quart. Journ. Geol. Soc. vol. ix. p. 132.—Edit.

‖ Signor Osculati, an Italian naturalist, who visited South America in 1846–8 ('Esplorazioni,' &c., Milano, 1 vol. 4to), alludes to bones of Mastodon found near Lake Papallacta, S.E. of Quito.

where something like fossil wood has been met with, and where also large excavations for nitrate of soda have been made for years past, some vestiges of fossil bones have been found*.

Dr. Phillipi, who was lately commissioned by the Chilian government to explore the Desert of Atacama†, does not mention the existence of fossil bones in that very large tract of country.

My late journey (1854) extended to south of Arauco in Chili, but no fossil bones of land animals could I find; nor could I learn that any had been met with.

When at Santiago de Chile, however, and making inquiries on the subject, my old friend, Mr. George Smith, H.B.M. consul there, presented me with a few fragments of fossil bones, taken by himself from the lake of Taguatagua, situated south of the capital; and the following is the account he gives me of them:—

"The Lake of Taguatagua is situated in the province of Colchagua, about 45 leagues from the capital due south, and at an elevation of 2300 feet above the level of the Pacific ocean. This lake is in the centre of the third range of hills which run from north to south in Chile, and is surrounded by very high hills called the Borbollon. The form of the lake is nearly oval, and about three leagues in circumference. The surrounding mountains are all of volcanic formation. The highest peak of the Borbollon is about 7000 feet above the margin of the lake. The body of water is supplied from springs,—it receives no streams from the mountains, and is generally as full in summer as in winter. It is shallow towards the edge, but slopes rapidly towards the centre, where I could find no bottom with 40 fathoms line. The sand on the shore is principally composed of very minute grains of iron-pyrites and small crystals. This lake is apparently the exhausted crater of a volcano.

"On the north side the hills decline, and form there, and there only, a low pass, through which, some years ago, it was proposed to cut for the purpose of draining the lake in part. A ditch was commenced from the margin of the lake towards the mountain, and in the progress of the work, at the depth of about 30 feet below the margin of the lake, were found the fossil bones. The first animal discovered was very perfect, with the exception of the head; and at a small distance another skeleton was found of smaller dimensions. Both were imbedded in a fine alluvial soil. As the width of the drain where the skeletons were found did not exceed 12 feet, we may conjecture that, had the trenches been wider, more remains would have been found. May not herds of these creatures have been destroyed whilst feeding on what at that time was an extended plain? I am inclined to this opinion, from having found fossil branches of trees in the same trench with the animals."

* In the Pampa de Tamarugal, province of Tarapacá, 3000 feet above the sea, bones, like those of mules, were found at the depth of 4 or 5 feet; and at another spot on this plain, bivalve shells, like cockles, are said to have been found in the rough nitrate of soda; and in digging a well thereabouts, bones of small mammals and of birds were met with.

† Journ. Roy. Geogr. Soc. vol. xxv. p. 158.

In the "Annals of the University of Chile" for 1850, there is a paper on the geology of that country, by Don V. Bustillos, in which, with reference to this lake, he says, "Another geological object of interest is the Lake of Taguatagua; it is now dried up. It formerly occupied a circular depression in the chain of mountains towards the coast, which are of secondary formation. Its shores were well wooded, and there was abundance of *Typha*, known as 'Tortora' or Flag; its waters were full of fish, the *Cyprinus* ('Pejerey,' or King-fish) predominating. This vicinity has been inhabited by gigantic extinct animals, the teeth of one of which, probably the *Mastodon*, are to be seen in the national museum at Santiago."

[Note.—The fragments of bone from the "Lake Taguatagua, 45 leagues south of Santiago de Chile," are parts of a femur and tibia of a *Mastodon*, probably *Mast. Andium*, Cuvier.—R. Owen, British Museum, Dec. 10, 1856.]

DONATIONS

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From January 1st, 1857, to March 31st, 1857.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

American Journal of Science and Art. 2nd Ser. Vol. xxiii. No. 67. January 1857. *From Prof. Silliman, For. Mem. G.S.*
- A. D. Bache.—Increase of Sandy Hook, 16.
- J. Le Conte.—Agency of the Gulf-stream in the formation of the Peninsula and Keys of Florida, 46.
- R. Bakewell.—Falls of Niagara, 85.
- Artesian Wells in Paris, 108.
- Aluminium, 111.
- R. P. Greg.—Meteorites from South America, 118.
- J. Higgins and C. Bickell.—Columbian Guano, 121.
- C. T. Jackson.—Serpentine-marbles of Vermont, 123.
- R. Owen.—Ruminantia and Aboriginal Cattle of Britain, 132.
- J. D. Dana.—Geological progress, 147.

Art-Union of London, Report of the Council, for 1856.

Assurance Magazine and Journal of the Institute of Actuaries. Vol. vi. part 6. No. 26. January 1857.

Athenæum Journal for January, February, March. *From C. W. Dilke, Esq., F.G.S.*
- Notices of Scientific Meetings, &c.

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- T. Thomson.—Botanical Geography of India, 414.

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R. Embleton.—Anniversary Address, 201.

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Scarabelli.—Descrizione della Carta Geologica della Provincia di Ravenna, 337.

Bianconi.—Repertorio Italiano per le Storia Naturale, 368. (Catullo, de Zigno, Reyneval, van der Heche, Ponzi, Ghirelli, Guidoni, Guiscardi, Bianconi, Calcara.)

Senoner.—Rivista degli studi di Mineralogia, Geologia e Paleontologia nella Monarchia Austriaca, 391.

Bianconi.—Se il mare abbia occupato le pianure e colli d' Italia, di Grecia, e dell' Asia Minore, 448.

Breslau. Drei und dreissigster Jahres-Bericht der Schlesischen Gesellschaft für vaterländische Kultur. Arbeiten und Veränderungen der Gesellschaft im Jahre 1855.

Duflos.—Ueber Alumium [Aluminium], 17.

Scharenberg.—Ueber die geognostischen Verhältnisse am Ostende des Altvater-gebirges, 22.

Czech.—Ueber die fossilen Insecten und Arachniden, verglichen mit den jetzt lebenden, 23.

Roemer.—Ueber die Auffindung eines fossilen Fisches der Gattung Acanthodes in Schwarzen Thonschiefer unweit Löwenburg, 25.

Cohn.—Ueber die Drehung der Baumstamme, 86.

Canadian Journal. New Series. No. 7. January 1857.

E. J. Chapman.—Fossils from Anticosti, 47.

Fossils from altered rocks in Eastern Massachusetts, 49.

Burrstone in Canada East, 49.

Red Oxide of Copper from California, 49.

Vanadinite, 49.

C. Daubeny.—Presidential Address to the British Association, 50.

A. D. Bache.—Cause of the increase of Sandy Hook, 67.

Charleston, Elliott Society, Proceedings, pp. 25–46.

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List of the Titles of Chemical [including Mineralogical and Metallurgical] papers in British and Foreign Journals, published in 1857, 301–371.

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Bonnissent.—Sur les Talcites de Gréville et sur les schistes du Rozel, 217.

Cherbourg, Société Impériale des Sciences Naturelles de, Mémoires (*continued*).
Lesdos et Besnora.—Analyse des limonites de Sauxmesnil, 387.
Th. du Moncie.—Une fissure remarquable dans un glacier, 401.

Civil Engineer and Architect's Journal. January 1857. No. 274.

———. February 1857. No. 275.
St. James's Park, 33.
C. H. Smith.—Induration of Stone, 51.

———. No. 276. Vol. xx. March 1857.
H. Austin, W. Ranger, and A. Dickens.—Water-supply, 73, 74.
L. D. Owen.—Artificial stone, 79.
W. W. Smyth.—Winding apparatus for Mines, 81.

Critic. Nos. 379, 380, 382.
Notices of Scientific Meetings, &c.
Summary of Geological Discovery for 1856, p. 607.
Mastodon-remains in Canada, 66.

Dublin Natural History Society, Journal (Proceedings), for 1855–56.
S. Haughton.—Analysis of Spodumene and Killinite, 24.

France, Société Géologique de la, Bulletin. Deux. Sér. Vol. xii. Feuilles 66–71 (1855).
Marie Rouault.—Notice sur quelques espèces du terrain dévonien du nord du département de la Manche (fin), 1041.
P. Mérian et J. Kœchlin Schlumberger.—Sur la formation de Saint-Cassian dans le Voralberg et dans le Tyrol septentrional, 1045.
Ch. Sainte-Claire Deville.—Extrait d'une lettre à M. Élie de Beaumont sur l'éruption du Vésuve du 1er mai 1855, 1065.
Ed. Piette.—Observations sur les étages inférieurs du terrain jurassique dans les départements des Ardennes et de l'Aisne (Pl. XXX.), 1082.
L. Pareto.—Sur l'âge des terrains à macignos, 1125.
Nérée Boubée.—Comment on pourrait rendre facile et rigoureuse la détermination des roches de sédiment, 1127.

———. ———. ———. Feuilles 72–77 (1855).
V. Raulin et J. Delbos.—Extrait d'une monographie des *Ostrea* des terrains tertiaires de l'Aquitaine, 1144.
Ed. Hébert.—Quelques renseignements nouveaux sur la constitution géologique de l'Ardenne française, 1165.
J. Delanoüe.—Addition à la communication précédente, 1187.
Marcel de Serres.—Des végétaux fossiles des schistes ardoisiers des environs de Lodève (Hérault), 1188.
Spada et Orsini.—Quelques observations géologiques sur les Apennins de l'Italie centrale (Pl. XXXII.), 1202.

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E. Morris.—On the Improvement of the Ohio River, 1.
Drainage of the Haarlem Mere, 15.
F. A. Abel.—The Composition of some varieties of foreign iron, 58.
J. P. Lesley's Manual of Coal, noticed, 70.

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C. H. Newell.—A submarine volcano, 1389.

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From Lovell Reeve, Esq., F.G.S.
Notices of Scientific Meetings, &c.
Notice of Dr. A. Ure, 41.
R. W. Mylne's Geological Map of London, noticed, 104.
J. Tyndall's views on Glaciers, 134.
E. Forbes's Memoir on the Isle of Wight Tertiaries, noticed, 269.

London, Edinburgh, and Dublin Philosophical Magazine. 4th Series. No. 82. Supplement. Vol. 12. January 1857.
From R. Taylor, Esq., F.G.S.
Scheerer.—Organic Acids in the Mineral Waters of Bruckenau, 538.
Heddle.—Mallet's Zeolitic Mineral [Laumonite] from Skye, 552.

———. ———. No. 83. Vol. xiii. January 1857.
P. J. Martin.—Anticlinal Line of the London and Hampshire Basins (continued), 33.
Heddle.—Mesolite and Faröelite, 50.
G. Bischof's Chemical and Physical Geology (Cavendish Soc.), noticed, 67.
Blanford's Translation of Scheerer on the Blowpipe, noticed, 70.
G. Buist.—Crystallization in Stucco, 76.
J. Morris.—Allophane at Charlton, 76.
J. Nicol.—Sandstones and Quartzites of N.W. of Scotland, 76.

———. ———. No. 84. February 1857.
Dr. Forbes.—On Tyrite, 91.
W. H. Miller.—On the Anharmonic ratio of radii normal to four faces of a crystal in one zone, 96.
P. J. Martin.—On the Anticlinal Line of the London and Hampshire Basins, 109.
S. Haughton.—On the Pitchstone-porphyry of Lough Eske, Donegal, 116.
E. Atkinson.—Chemical notices from Foreign Journals, 118.
F. A. Weld.—Volcanic Eruption of Mauna Loa, 145.
T. Coan.—Volcanic Eruptions in Hawaii, 146.
Miller.—Volcanic Eruption of Mauna Loa, 146.
Campbell.—Earthquake at Rhodes, 146.
T. Spratt.—Geology of Bulgaria, 146.
—— Freshwater deposits in Eubœa and Salonika, 146.
T. Richardson and E. J. J. Browell.—Analyses of waters from the Turko-Persian Frontier, 147.
J. Wolley.—An Ice-carried boulder at Borgholm, 147.

London, Edinburgh, and Dublin Philosophical Magazine. No. 84. February 1857 (*continued.*)
W. B. Clarke.—Volcanic bombs in Australasia, 147.
H. J. Moyle and C. B. Hillier.—Metalliferous ores in Siam, 147.
Heddle.—The Antrimolite of Thomson, 148.

———. ———. No. 85. March 1857.
A. Sedgwick.—Remarks on a passage in the President's Address, 15th February, 1856, 176.
R. Owen.—*Dichodon cuspidatus*, 209.
—— A fossil Ophidian from Salonika Bay, 210.
J. W. Salter.—Some additional fossils from the Longmynd, 211.
W. Thomson.—Some species of *Acidaspis* from South Scotland, 211.
J. W. Salter.—Some species of *Acidaspis* from Shropshire, 211.
J. Prestwich.—Some Fossiliferous Ironstone (Crag), from the North Downs, 211.
J. W. Kirkby.—Some Permian Fossils from Durham, 213.
J. Cleghorn.—Rock-basins, 213.
R. N. Rubidge.—Copper-mines of Namaqualand, 214.

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———. ———. Vol. iv. 3ª Serie. Cienc. Nat. Tomo ii. Parte 1. 1856.
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J. B. P. Dennis.—Bones of Birds in the Stonesfield Slate, 63 (plate).
J. W. Bailey.—Origin of green sand, and its formation in the existing oceans, 83.

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F. E. Edwards.—The Eocene Mollusca of England, Prosobranchiata. Part 3, No. 2.
D. Sharpe.—Mollusca of the Chalk of England, Cephalopoda, part 3.
T. R. Jones.—The Tertiary Entomostraca of England.
T. Wright.—British Fossil Echinodermata, part 1.

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Bibliographie, i.
Chatoney.—Sur les matériaux hydrauliques, 505.
Friedel.—Sur deux cristaux de zircon basés, 629 (plate).
J. B. Trask.—Exploitation de l'or en Californie, 649.
R. Hunt.—Statistique de l'industrie minérale du Royaume-Uni en 1854, 668.

———. ———. ———. Vol. x. 4e Livr. de 1856.

Chatoney.—Sur les matériaux hydrauliques, 1.
Damour.—Sur l'hydro-apatite, 65.
Gruner.—Essais de combustibles, 73.
F. Pisani.—Sur un nouveau moyen de doser l'argent par boie humide au moyen de l'iodure d'amidon, 83.
Parran.—Sur les formations secondaires des environs de Saint-Affrique (Aveyron), 91.

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Lord Wrottesley's Anniversary Address. Obituary Notices of Buckland, Crichton, Sharpe, &c., 240.

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P. P. King.—Specific gravity of sea-water, 291.
F. Field.—Silver in sea-water, 292.
W. S. Jacob.—The Earth's mean density, 295.
R. Owen.—The *Scelidotherium leptocephalum*, 312.
J. Tyndall and T. H. Huxley.—Glaciers, 331.

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H. W. Reveley.—Brown lime, 130.

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Quenstedt.—Gavial und Pterodactylus Württemberg's, 34 (plate).

Von Schübler.—Gasausströmungen im Schacht bei Haigerloch, 44.

Von Jaeger.—Ueber Ichthyosaurus longirostris, 54.

Schuler.—Ueber die Rutschflächen im Wasseralfinger Eisenerze, 56.

Fraas.—Die Oolithe im weissen Jura des Brenzthals, 104.

Deffner.—Conservirung von Petrefacten, 108.

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R. Howse.—Permian system of Durham and Northumberland, 33 (plate).

J. Lycett.—*Quenstedtia*, 53.

P. B. Brodie.—Inferior Oolite and Lias of Northamptonshire and Gloucestershire, 56.

—— New species of *Pollicipes* from the Inferior Oolite and Lias of Gloucestershire, 102.

R. Owen.—*Stereognathus Ooliticus* from the Stonesfield Slate, 103.

T. R. Jones.—*Estheria minuta,* and distribution of the fossil *Estheriæ,* 103.

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Ansted's Elementary Course of Geology, &c., noticed, 166.

R. Owen.—On the *Dichodon cuspidatus,* 184.

—— On a fossil Ophidian from Salonica, 185.

J. W. Salter.—On some additional fossils from the Longmynd, 186.

W. Thomson.—On some *Acidaspides* from Scotland, 187.

J. W. Salter.—On some *Acidaspides* from Shropshire, 187.

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W. B. Carpenter.—Structure of the shell of *Rhynchonella Geinitziana*, 214.

R. Owen.—The *Scelidotherium*, 249.

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W. Crowder.—Average Composition of the Rosedale, Whitley, and Cleveland Ironstones, 35.

E. Hull.—The Basalts of Antrim, 53 (plate).

W. J. Henwood.—The copper-turf of Merioneth, 61.

G. Wilson.—The physical sciences which form the basis of Technology, 64.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 8, 1857.

The Rev. H. Brass, B.A., Brompton, Chatham, Kent, was elected a Fellow.

The following communication was read:—

On the Species of Mastodon *and* Elephant *occurring in the fossil state in* Great Britain. Part I. Mastodon. By H. Falconer, M.D., F.R.S., F.L.S., & F.G.S.

[Plates XI. & XII.]

Contents.

Introduction.—It is of the highest importance to Geology, that every mammal found in the fossil state should be defined as regards, 1st, its specific distinctness, and, 2ndly, its range of existence geographically and in time, with as much exactitude as the available materials and the state of our knowledge at the time will admit. Every form well ascertained becomes a powerful exponent; while, ill-determined, it is a fertile source of error. For the pure Geologist, in most of his conclusions where age or climatal conditions are in question, is more or less at the mercy of the Palæontologist, since he must accept the palæontological evidence as it is laid before him, and square his speculations to fit and dovetail into the various mortises which the data inexorably present to him. There is a subordination in the value of the evidence: the higher the form in the scale of organization, the more weighty is the import of its indications.

The difficulty with which the Mammalian-palæontologist has to contend in arriving at satisfactory results depends doubtless in many cases on the imperfect nature and scantiness of his materials. But it is deserving of remark, that the fossil genera and species which are in the most unsatisfactory and unsettled state, as to definition and nomenclature, are not those that are the rarest, but often the reverse. Take *Mastodon* or *Rhinoceros* for example, in which the array and confusion of specific names are signally perplexing. The reason of this apparent anomaly would seem to be this,—when the remains are few and seldom met with, the species are usually limited in number, and thus more easily discriminated; on the other hand, when the remains are very abundant over wide areas, the species are at the same time, as a general rule, numerous: and it is well known among naturalists, that the genera which are the most difficult to disentangle specifically are the most complete and natural, where the species are many, and follow each other with the least amount of difference in serial development; or, in other words, where they are most closely allied to one another.

Remains of either of the Proboscidean genera, *Dinotherium*, *Mastodon*, and *Elephas*, abound in all the Tertiary Formations of Europe, Asia, and America, from the Miocene up to the Post-pliocene; they have been the subject of a vast amount of observation, while it is hardly possible to conceive anything more unsettled and opposed than the generally received opinions respecting the species and their nomenclature in the standard works which are of the greatest authority on the subject. Cuvier, De Blainville, and Owen are agreed in limiting the Elephants and narrow-toothed Mastodons found fossil in Europe each to a single species; while other palæontologists consider that the latter group comprises at least three well-marked specific forms, and the former three or four. This palæontological uncertainty has naturally been reflected in systematic works on Geology, wherever the faunas of the Tertiary Formation are referred to, in statements sufficiently startling, which are repeated at the present day. Thus the Miocene *Mastodon angustidens*, of the Faluns of Touraine, of the Molasse of Switzerland, and of the Sub-Pyrenees, as also the Miocene *Mastodon longirostris* of Eppelsheim, are mentioned by Sir Charles

Lyell, in the 5th edition of his Manual*, under the comprehensive name (on the authority of Owen) of *Mastodon angustidens*, as occurring in the so-called "Older Pliocene" Red Crag, and in the "Pleistocene" Norwich Crag: while this English species of Mastodon, wherever it has been met with, whether in this country or on the Continent, has been almost invariably found in company with remains of a species of Elephant which Professor Owen has described as identical with the *Elephas primigenius* or Mammoth of the Post-pliocene Drift and the modern Siberian ice-fields.

The object of the present communication is, to endeavour to ascertain what are the species of Mastodon and Elephant found fossil in Britain; what the specific names which ought to be applied to them; and what the principal formations and localities where they are elsewhere met with in Europe. I am the more induced to attempt the task from the circumstance, that Prof. Owen in an important memoir "On some Mammalian Fossils from the Red Crag of Suffolk," which appeared in a late number of the Society's Quarterly Journal†, adheres to the opinion expressed in his Report to the British Association for 1843, and subsequently discussed at greater length in his 'British Fossil Mammalia' in 1846, that the Mastodon of the English Crag is identical with the *Mastodon angustidens* of Cuvier, the *Mastodon longirostris* of Kaup, and the *Mastodon Arvernensis* of Croizet and Jobert. Prof. Owen, on both the occasions here quoted, up to 1846, has maintained the prevalent opinion, that all the Elephant-remains met with in England are referable to a single species, namely *Elephas primigenius*; and I am not aware that he has altered his views upon this point in any subsequent publication. I have devoted much study to the subject, during the last 15 years, in connexion with the numerous fossil species of both genera, which are met with in India, with a view to a monograph of the Proboscidean family, fossil and recent. The results to which I have been conducted, as to the disputed European species, are different from those arrived at by Prof. Owen. The most of those results have been long exhibited, so far as figured evidence goes, in the published illustrations of the 'Fauna Antiqua Sivalensis'‡: but, having devoted the last summer and autumn to a Proboscidean examination, so to speak, of some of the principal collections on the Continent, with special reference to the European fossil species, I have been enabled to confirm or correct previous conclusions on a wider field of observation. In order to avoid needless repetition in the sequel, I may mention that the tour here referred to embraced a detailed study of the very extensive collection of Val d'Arno Proboscidean remains contained in the Museum at Florence; the collections of Turin, Milan, and Pavia; of Geneva, Lausanne, Berne, Zurich, Basle, and Winterthur in Switzerland; of Darmstadt, Mannheim, and Strasbourg on the Rhine; of the Jardin des Plantes and Ecole des Mines in Paris; the Duc de Luynes' fine collection of the Chartres fossil Elephant, in Chateau Dampierre; and the surpassingly rich and unrivalled collection made by my friend

* *Op. cit.* p. 156. † No. 47, vol. xii. part 3. Aug. 1, 1856, p. 223.
‡ Fauna Antiq. Sivalens. Illustr. par. v. pl. 42–45.

M. Lartet, of the Sub-Pyrenean Proboscidea, at Seissan on the Garonne; together with some of the principal collections at Toulouse. In one or other of these museums I had opportunities of studying all the fossil species hitherto described as having been met with in Europe, together with one fine species of Mastodon discovered by M. Lartet, but which has not yet been published.

Generic distinctions and nomenclature of the Proboscidea.—Before entering on the special consideration of the British fossil forms, it will be necessary to give some explanation of the principles on which the genera have been limited, and subdivided into subgeneric groups, in order to comprehend the reasons for the nomenclature adopted in this communication. A detailed palæontological disquisition would be out of place on the present occasion. Such salient points only will be touched upon as are essential to the elucidation of the subject.

The Proboscidean species, fossil and recent, constitute a large group, embracing at least 25 distinct forms, which are comprised under the three genera of *Dinotherium, Mastodon,* and *Elephas.* These genera, regarded in a systematic view, are of very unequal value numerically; the first being very limited in the number of ascertained species, but defined by well-marked generic distinctions; while the last two represent a large number of specific forms, which, although their opposite extremes are widely separated, yet are connected together through so complete and natural a series of intermediate specific links, that it has proved difficult to devise good generic characters to distinguish them. Putting aside all other considerations of structure and form, the diagnostic marks will be regarded on the present occasion solely as they are furnished by the teeth and jaws.

(*Dinotherium.*)—The adult dentition of *Dinotherium* * is characterized by two vertically succeeding premolars and three true molars, five teeth in all, with transverse crenulated ridges closely resembling those of the Tapir; and by two huge inferior recurved incisors, implanted in an enormously thickened and deflected beak or prolongation of the symphysis of the lower jaw. Most of the molar teeth present the normal Tapir-like crown-character of two ridges; but, when the milk- and permanent dentition are taken together, *Dinotherium* differs from all the non-elephantoid Pachydermata in the circumstance that the last milk-molar and antepenultimate true molar (being contiguous teeth in the order of horizontal succession) present a more complex development of three ridges, or, a "ternary-ridged crown-formula" (to use a term which will be found of importance in the sequel). Two species only of *Dinotherium* have, I believe, hitherto been met with; the one in Europe, and the other in India†. The European species, *D. giganteum,* occurs in the

* Kaup, Akten der Urwelt (1841), pp. 22–40.

† As in the case of the Mastodon of North America, numerous nominal species have been founded by different authors (Kaup, Von Meyer, Eichwald, &c.) upon what would appear to have been merely varieties of the same species, depending on race, sex, &c., as evinced by the comparative size of the teeth. Dr. Kaup now

Older Miocene formations, such as Eppelsheim, the Faluns of Touraine, and the Molasse and lacustrine strata of the Sub-Pyrenees: it has nowhere been met with in Britain.

(*Mastodon and Elephas.*)—Up to the date of the last 4to edition of the 'Ossemens Fossiles' published during the author's life in 1825, the species of *Mastodon* and *Elephas* then known were sufficiently well distinguished by the characters indicated by Cuvier*, the founder of the former genus; namely, that the molar teeth of *Mastodon* consisted of a comparatively simple crown, divided into mammillæ or tubercles, arranged in transverse ridges, more or less numerous, and more or less prominent, with corresponding empty valleys or hollows between them; while those of *Elephas* were more complex, consisting of numerous thin transverse plates, having their intervals filled up with cement. The subsequent discovery of the *Mastodon elephantoides* of Clift, in which Cuvier's characters of both genera are blended, and of European and American forms with tusks in the lower jaw (*Mastodon longirostris* and *Mastodon Ohioticus*), led to the necessity of remodelling the technical diagnostic characters of the genera. This was first attempted, so far as I am aware, by Bronn of Heidelberg, in his 'Lethæa Geognostica,' as far back as 1838. In his elaborate definition of the two genera he states (omitting other characters) that Mastodon is characterized by lower incisors, and by molars which are replaced from back to front, excepting, however, the most anterior of these teeth, *i. e.* one or more milk-molars; while in Elephant there are no inferior incisors, and *all* the molars are replaced in a horizontal direction†. In his remarks upon the species, he mentions that "Tetracaulodon (i. e. *Mastodon longirostris*), according to Kaup, has premolars in the upper jaw, which are very similar to the back molars of Hippopotamus and are very caducous‡," and in regard to inferior tusks, that "*Mastodon giganteus*, *M. angustidens*, and *M. longirostris* do unquestionably possess such inferior tusks: the other species of Mastodon occur more rarely, and we can therefore only by analogy infer their having possessed them also§." The same characters, *i. e.* of premolars and

entertains doubts of there being any other European species than *D. giganteum*[a]; the difference of size between the teeth of *D. giganteum* and *D. Cuvieri* is not greater than is known to occur between homologous teeth from different individuals of *M.* (*Tetraloph.*) *longirostris*, dug out of the same deposit at Eppelsheim. The nominal species *D. Kœnigii* of Kaup is founded on a single small tooth, and therefore doubtful. I have lately seen well-marked specimens of fossil teeth of a species of Dinotherium from Attock in the Punjab, at no great distance from the Sewalik Hills, and, judging from the associated Mammalia, out of beds of the same age with them. The materials are not sufficient to establish whether the species is identical with *D. Indicum* of Perim Island, or distinct. In dimensions the teeth correspond with medium-sized specimens of *D. giganteum*. They were discovered by Lieut. Garnett, of the Bengal Engineers, and are now in the possession of Prof. Oldham, Superintendent of the Geological Survey of India, who has obligingly communicated them to me.—July 1857, H. F.

* Oss. Fossiles, tom. i. p. 205.

† Bronn, Lethæa Geognostica, Band ii. pp. 1233 & 1239 (1st ed.).

‡ Id. *loc. cit.* p. 1218. § Id. *loc. cit.* p. 1233.

[a] Akten der Urwelt, p. 49.

inferior incisors, were several years afterwards advanced by Prof. Owen (who must obviously have overlooked the previous remarks of Bronn) in his 'British Fossil Mammalia*' as being distinctive of Mastodon from Elephant in a well-marked and unequivocal manner. But they are assuredly neither absolute nor constant, whether regarded in a positive or negative view, as generic distinctions. For on the one hand, premolars have not yet been met with in *M.* (*Trilophodon*) *Ohioticus*, in place in the jaws, although made a subject of special research by Dr. Warren, Dr. Jackson, and myself, upon a large quantity of materials†, up to a very late date; nor have they been yet met with in certain species of the *Tetralophodon* group; while, so far from being restricted to species of Mastodon, they have been detected by us in a typical fossil Elephant from India, *E.* (*Loxodon*) *planifrons*, both in the upper and lower jaws, in as great a number as in any known Mastodon. And as regards inferior tusks, although these have been observed in three species of the *Trilophodon* group, and in two of *Tetralophodon*, there are other species in which, among abundant materials, they have not been noticed up to the present time, even in young individuals, where they might have been with most confidence looked for. This remark applies with especial force to the forms here called *M.* (*Trilophodon*) *Humboldtii*, and to *M.* (*Tetralophodon*) *Sivalensis* and *M.* (*Tetralophodon*) *Arvernensis*.

Swayed by considerations of this nature, and struck more particularly with the identity of general characters, and close similarity of form, running throughout the whole of the osteology of the species of Mastodon and Elephant, with the exception of the molars and inferior incisors, De Blainville‡ abandoned the idea of there being any sufficient generic difference between the two, and made a retrograde step, arranging all the forms in two divisions, *Lamellidontes* and *Mastodontes*, under the common designation of "Elephas." This proposal has deservedly met with little favour among palæontologists and zoologists.

There are characters however, which, when once recognized, are happily of an obvious and readily applicable nature to distinguish Mastodon from Elephant, and which further enable the palæontologist to break up an unwieldy mass of species into subgeneric groups, that are at the same time natural and convenient. Putting aside for the moment, as extraneous, the consideration of incisors and premolars, and, as in the case of Dinotherium, taking the milk- and permanent dentition together, the species of both Mastodon and Elephant ordinarily present six molar teeth from first to last, in the order of horizontal succession, *i. e.* three deciduous or milk-molars, and three true molars. It was stated above, that in the *Dinotherium* the last milk-molar and the antepenultimate or first true molar are invariably characterized by a ternary-ridged formula, or in other words, that their crowns are divided into three ridges. Applying this criterion in a similar manner to *Mastodon*, we have found, that not only the last milk- and first or antepenultimate true-molar, but in addition

* Brit. Foss. Mam. p. 274. † Warren, On *Mastodon giganteus*, p. 80.
‡ De Blainville, Ostéographie : Des Eléphants.

the second or penultimate true molar, being three teeth in immediate contiguity, in all the species (with one remarkable exception) are severally characterized in both jaws by an *isomerous* division of the crown into either 3 or 4 ridges. These three isomerous-ridged teeth may, for convenience of description, be referred to in the aggregate as "the intermediate molars," a term which has been applied to them from their position by Fischer and by Laurillard*. To the species which present the ternary-ridged formula we have assigned the subgeneric name of *Trilophodon*†; and to the quaternary-ridged species, *Tetralophodon*‡. In citing the various forms under discussion in the sequel, these subgeneric terms will, in every case, be used for convenience in designating the species; and the same rule will be followed with the subgeneric divisions of *Elephas*. This will be of obvious use on the present occasion, both as a help to the memory in dealing with a large number of specific names, and as suggestive of broad points of distinction, when referring to the disputed species.

The ternary and quaternary formulæ are, I believe, never found mingled in the intermediate molars of the same species§; *i. e.* a ternary-ridged molar of this series does not occur in the species belonging to *Tetralophodon*, nor a quaternary in *Trilophodon*. The ridge-formula indicates also, with unerring certainty, the composition

* Dictionnaire Universel d'Histoire Naturelle, tom. viii. p. 29.

† From τρεῖς et λόφος, three-ridged.

‡ From τέσσαρα et λόφος, four-ridged. This difference of *three* and *four* ridges was, so far as I am aware, first pointed out as a distinctive character between two European species, namely *Mastodon angustidens* and *Mastodon Arvernensis*, by Von Meyer as far back as 1834, but without being extended to the three intermediate molars. The name *Mastodon Arvernensis* was applied by him to the Eppelsheim species, *Mastodon longirostris* of Kaup. (Die Fossilen Zahne und Knochen von Georgensgmünd, p. 33.) The ridge-formula in the two subgenera is as follows:—

	Milk-molars.		True molars.
In Trilophodon	$\frac{1+2+3}{1+2+3}$	:	$\frac{3+3+4}{3+3+4}$
In Tetralophodon	$\frac{2+3+4}{2+3+4}$	:	$\frac{4+4+5}{4+4+5}$

the numerals exhibiting the ridges in each tooth, exclusive of the "talons."

§ The only apparent exception which has come under my observation, occurs in the dentition of the South American species, to which the name of *Mastodon Andium* (Tetralophodon of our arrangement) has been restricted by the French palæontologists, Laurillard and Gervais, as distinct from *M. Humboldtii* (Trilophodon). In this species the last ridge in most of the intermediate molars is considerably reduced in size; and the teeth have been, in consequence, described by Gervais (Zoologie de l'expédition dans l'Amérique Méridionale par Le Comte de Castelnau, p. 19) as three-ridged. The specimens represented by him, figs. 2 and 5 of pl. 5 in the 'Voyage de Castelnau,' the former an antepenultimate upper true molar, and the latter a penultimate lower, are distinctly four-ridged, while the last lower milk-molar, fig. 4, is apparently three-ridged, with a large talon. My attention was directed to the subject by M. Lartet. More specimens are required for the exact determination of the point than yet exist in any of the European museums; *i. e.* whether in the intermediate molars of the form called *Mastodon Andium* the ternary and quaternary formulæ are mingled. Nine-tenths at least of the specimens of South American Mastodons in the British Museum belong to the other species, *M.* (*Trilophodon*) *Humboldtii*.—July 1857, H. F.

of the crown of the tooth which is immediately in front of, and of that which is immediately behind, the three intermediate molars: the former showing invariably *one* ridge less, and the latter *one* ridge more; that is to say, the penultimate or second milk-molar in all the species of *Trilophodon* is invariably two-ridged, and the last true molar four-ridged; while in *Tetralophodon*, in like manner, the former is three-ridged, and the latter five-ridged,—making due allowance in the last true molar for the amount of individual variety presented by the greater or less development of the well-known talon-complication, and for its being usually more complex in the lower jaw. The "ridge-formula" thus determines, with precision, five out of the series of six molars developed in horizontal succession in all the true Mastodons.

For reasons which will be explained in the sequel, it would seem that there has existed in nature another subgeneric group of *Mastodon*, of which only a single form is at present known, in which the crowns of the "intermediate molars" are divided upon a quinary ridge-formula. This group in our arrangement would be characterized, in harmony with the others, as *Pentalophodon*: and it may with some confidence be predicated, that, when the dentition shall have been well determined, the second milk-molar will present four ridges, and the last true molar six ridges in the upper jaw.

The Elephants, on the other hand, are distinguished from the Mastodons by the absence of an isomerous ridge-formula to the three intermediate molars of the upper and lower jaws; and by the circumstance that the ridges, instead of being limited to three or four, range from six up to an indefinite number in these teeth, in the different groups of species. We have found that the numerous forms, fossil and recent, may be conveniently arranged in three natural subgeneric groups, founded upon the ridge-formula, in conjunction with certain other dental characters.

In the first of these groups, corresponding with the forms collectively designated *Mastodon elephantoides* by Clift, the ridge-formula may be said to be *hypisomerous*, as the difference between the crowns of any two of the consecutive intermediate teeth does not exceed more than one ridge, and the ciphers range in the different species from 6 to 8. The ridges are not more elevated than in the true Mastodons, so that, when the teeth are sawn through longitudinally, the section yields a succession of salient and re-entering angles, the height of the chevron-shaped ridges not much exceeding the width of their base. The enamel is very thick, and the coronal interspaces in most of the species are filled up with an enormous quantity of cement. To this group we have assigned the subgeneric name of *Stegodon**. It is limited to extinct forms confined at present to the Indian Tertiaries. The Stegodons constitute the intermediate group of the Proboscidea from which the other species diverge through their dental characters, on the one side into the Mastodons, and on the other into the typical Elephants.

In the second group, which includes the species allied to the

* From στέγη *tectum*, and ὀδοὺς *dens*, having reference to the gable-end form of the section of the ridges.

African Elephant, the ridge-formula is also hypisomerous, as in the Stegodons, the ciphers ranging from 7 to 9 in the crown-ridges of the intermediate molars of the different species. But the colliculi, instead of yielding a gable-shaped or "tectiform" section as in the Stegodons, are much more elevated and compressed, so that when the teeth are sawn longitudinally and vertically, the ridges present the appearance of elongated wedges, with thinner plates of enamel. For this subgeneric group, the name of *Loxodon**, first indicated by Frederick Cuvier, has been adopted. It comprises both extinct and living species.

The last group, which is numerically the largest and most important, including the Elephants with thin-plated molars, as in the existing Asiatic species, is characterized by the ridge-formula being regulated in the "intermediate molars," not by hypisomerous ciphers, but by progressive increments (*anisomerous*), which may be expressed (*e. g.* for the Indian Elephant) by the series 12 + 14 + 18 †. These ciphers, be it remarked, are not put forward as being rigidly exact in every case: for the higher the numerical expression of the ridge-formula in the species, the more liable to vary within certain limits, dependent on the race, sex, and size of the individual, is the number of the plates; and they do not rigidly correspond throughout in the upper and lower molars, the latter often exhibiting an excess. But it may safely be asserted that the numbers are never transposed or reversed, *i. e.* the younger tooth among the "intermediate molars" never normally exhibits in the same individual a higher number than the older; the increments may not always be symmetrical, but they are invariably more or less progressive. For this subgeneric group we propose the term of *Euelephas*‡.

[*Note.*—The following systematic Diagnoses of the genera *Mastodon* and *Elephas* were prepared as an Appendix by the author, but their insertion in this place more conveniently elucidates the subject-matter of this memoir. —Edit.]

* From λοξὸς *obliquus*, and ὀδοὺς *dens*, having reference to the rhomb-shaped discs of the worn molars; an adaptation of the term "*Loxodonta*" proposed by Fred. Cuvier, 'Hist. Naturelle des Mammifères,' tom. iii., Article "Eléphant d'Afrique." 1835.

† The illustration in this case is taken from the existing Indian Elephant, *E.* (*Euelephas*) *Indicus*, in which the ridge-formula of the whole series is nearly thus:—

$$\text{Milk-molars. } \frac{4+8+12}{4+8+12} : \text{ True molars. } \frac{14+18+24}{14+18+24-27}$$

the numerals representing the ridges in each tooth, exclusive of the talons. A progressive increment runs throughout the series: but the selected numbers refer only to the "intermediate molars." In the species which approach nearest to *Loxodon*, the numerical expression of the ridge-formula is lower.

‡ From εὖ *bene*, and ἐλέφας, having reference to the typical Elephants most familiarly known. In the illustrations of the 'Fauna Antiqua Sivalensis,' the term *Elasmodon* was applied to this subgeneric group: but, the designation of *Elasmodus* having been preoccupied by Sir Philip Egerton for a series of fossil fish (Proc. Geol. Soc. vol. iv. p. 163, 1843), to prevent confusion, the term of *Euelephas* has been substituted for it.

Genus Mastodon (Cuv.).

Formula Dentium deciduorum.—*Primores* $\frac{1}{1}$ vel $\frac{1}{0}$; *Laniarii* $\frac{0}{0}$; *Molares* $\frac{3}{3}$=8–7.

Formul. Dent. persist.—*Primor.* $\frac{1}{1}$ vel $\frac{1}{0}$; *Lan.* $\frac{0}{0}$; *Præmol.* $\frac{2}{2}$ $(\frac{1}{1}?)$ vel $\frac{0}{0}$; *Molares veri* $\frac{3}{3}$ =12–8.

Primores eburnei plerumque exserti: superiores maximi vario modo porrecti, inferiores horizontales vel leviter deflexi, recti, minores. *Molares* complicati, tritores; *coronidis* rimâ longitudinali obsolete bifidæ *colliculi* concavi e tuberculis mammillaribus per paria transversè aut alternatim dispositis, constantes: *adamante* crasso, *cæmento* in valliculis parco aut subnullo. *Præmolares* aut cæteris formâ simpliciores minores, aut nulli. *Molares veri* 3, deinceps majores, altero alterum extrusum a tergo vicissim excipiente, demum utrinque solitarii.—*Molares* 3 utrinque *intermedii* (nempe deciduorum postremus et verorum antepenultimus penultimusque) *colliculis* isomeris aut 3, 4, aut 5 conformes.

Proboscis longissima, prehensilis. *Corpus* vastum artubus elevatis insistens. *Pedes* 5-dactyli.

Subgenus 1. Trilophodon.—Dentium molarium 3, utrinque intermediorum coronis colliculis 3.

Subgenus 2. Tetralophodon.—Dent. molar. 3, utrinque intermediorum coronis colliculis 4 (raro 5).

Observations.—The adult dentition varies much in the different species of the genus; the premolars and inferior incisors being inconstant. The typical complete formula is best shown by *M.* (*Triloph.*) *angustidens* of Simorre:—*Incis.* $\frac{1}{1}$; *Can.* $\frac{0}{0}$; *Præmol.* $\frac{2}{2}$; *Mol.* $\frac{3}{3}$ =12, being identical with that of *Dinotherium*, so far as the dentition of the latter has been determined, *i. e. Incis.* $\frac{1?}{1}$; *Can.* $\frac{0}{0}$; *Premol.* $\frac{2}{2}$; *Mol.* $\frac{3}{3}$ = 12; the only question being in regard of upper incisors, the presence or absence of which has not yet been clearly ascertained in *Dinotherium*. The affinity indicated by the agreement in number is corroborated by the last milk-molar and ante-penultimate true molar being three-ridged alike in *Dinotherium* and in the section of *Mastodon* here called *Trilophodon*. Premolars have not been met with in *M.* (*Triloph.*) *Ohioticus*, which, counting both sides of both jaws, has 8 molars less in the adult state than *M.* (*Triloph.*) *angustidens*; nor have they been observed in *M.* (*Triloph.*) *Humboldtii*. They occur probably in *M.* (*Triloph.*) *tapiroides*. Their presence or absence has not yet been ascertained in the other species of *Trilophodon*. These teeth have been observed *in situ* in the upper and lower jaws of *M.* (*Tetraloph.*) *longirostris*, and in the upper of *M.* (*Tetral.*) *Arvernensis*. They have not yet been seen *in situ* in the other species of *Tetralophodon*.

Inferior incisors have been discovered in *M.* (*Triloph.*) *angustidens*, *M.* (*Triloph.*) *Ohioticus*, and *M.* (*Triloph.*) *tapiroides*; and also in *M.* (*Tetraloph.*) *Andium* and *M.* (*Tetraloph.*) *longirostris*, in the first of which they occasionally attain a very large size. They do not appear to occur ever in *M.* (*Tetraloph.*) *Sivalensis*, nor in *M.* (*Tetraloph.*) *Arvernensis*. Their presence or absence in the two other species of *Tetralophodon* has not yet been satisfactorily determined. The ridge-formula, as being respectively ternary in *Trilophodon* and quaternary in *Tetralophodon*, is very constant, the only doubtful case being presented by the form or forms named *Mastodon Andium* by the French palæontologists. Cement, although quantitatively inconspicuous in most of the species of both subgenera, is present in considerable abundance in the valleys of the crowns of *M.* (*Tetralophodon*) *Perimensis* and in *M.* (*Triloph.*) *Humboldtii*. In the former it fills up the bottom of the interstices between the mammillæ. The transverse or alternate direction of the mammillæ of the ridges, and the open or interrupted nature of the valleys connected therewith, are not equally defined in all the species, intermediate stages being met with. But the ridges are invariably transverse and the valleys open in *M.* (*Triloph.*) *Borsoni*, *Ohioticus*, and *tapiroides*, and in *M.* (*Tetraloph.*) *latidens*; while the mammillæ are constantly more or less alternate, and the valleys interrupted among the Trilophodons in *M.* (*Triloph.*) *angustidens*, *Humboldtii*, and *Pandionis*; and among the Tetralophodons in *M.* (*Tetraloph.*) *Sivalensis* and *Arvernensis*. The most complex crowns are presented in the Trilophodons by *M.* (*Triloph.*) *Pandionis* (an Indian fossil species recently discovered and as yet undescribed), and *M.* (*Triloph.*) *Humboldtii*; and among the Tetralophodons by *M.* (*Tetraloph.*) *Sivalensis* and *Arvernensis*. The upper adult molars in several of the species (e. g. *M.* (*Triloph.*) *angustidens* and *M.* (*Tetraloph.*) *Andium*) were invested with a longitudinal belt of enamel, disposed more or less spirally, and reaching the apex. The lower incisors, according to Lartet, are constantly devoid of any such belt. In *M.* (*Triloph.*) *angustidens* inferior incisors would appear to have been common to males and females, and not to have been a mark merely of sexual difference. *Mastodon Sivalensis*, although with five-ridged "intermediate molars," is provisionally included under *Tetralophodon*.

Genus ELEPHAS (Linn.).

Form. Dent. decid.—*Primor.* $\frac{1}{0}$; *Lan.* $\frac{0}{0}$; *Mol.* $\frac{3}{3} = 7$.

Form. Dent. persist.—*Primor.* $\frac{1}{0}$; *Lan.* $\frac{0}{0}$; *Præmol.* $\frac{2}{2}$ vel $\frac{0}{0}$; *Mol.* $\frac{3}{3} = 11\text{–}7$.

Primores eburnei plerumque exserti, sursum et antrorsum adscendentes. *Molares* aut complicati aut lamellosi, tritores; *coronidis* longitudinaliter integræ *colliculi* convexi e tuberculis mammillaribus, aut laminis cuneiformibus vel compressis digitatis transversis, constantes: *adamante* illis crasso, his attenuato, *cæmento* in valliculis copioso. *Præmolares* rarissime utrinque 2 (sæpius nulli), cæteris forma simpliciores, minores. *Molares* *veri* 3, deinceps majores, altero alterum extrusum a tergo vicissim excipiente, demum utrinque solitarii.—Molares 3 utrinque intermedii (nempe deciduorum postremus et verorum antepenultimus penultimusque) *colliculis* supra 5 (6–18), aut hypisomeris, aut anisomeris.

Proboscis longissima, prehensilis. *Corpus* vastum artubus elevatis insistens. *Pedes* 5-dactyli.

Subgen. 1. STEGODON.—Dentium molarium 3 utrinque intermediorum coronis complicata colliculis hypisomeris (*e. g.* 7+7+8), mammillatis, tectiformibus. Præmolares nondum observati.

Subgen. 2. LOXODON.—Dent. molar. 3 utrinque intermedior. coronis lamellosa colliculis hypisomeris (*e. g.* 7+7+8), cuneiformibus. Præmolares raro utrinque 2.

Subgen. 3. EUELEPHAS.—Dent. molar. 3 utrinque intermedior. coronis lamellosa colliculis deinceps numero auctis, anisomeris (*e. g.* 12+14+18), attenuatis, compressis. Præmolares nulli.

Observations.—The adult dentition of the Elephants, although typically more aberrant, is more constant than that of the Mastodons. Inferior incisors are wanting in all the species, fossil and recent, at present known; and premolars have as yet only been met with in a single form, *E.* (*Loxodon*) *planifrons*. The common formula is, *Incis.* $\frac{1}{0}$; *Can.* $\frac{0}{0}$; *Præmol.* $\frac{0}{0}$; *Mol.* $\frac{3}{3}=7$; but in this exceptional case the premolars are as numerous as in any species of *Mastodon*, the formula being, *Incis.* $\frac{1}{0}$; *Can.* $\frac{0}{0}$; *Præmol.* $\frac{2}{2}$; *Mol.* $\frac{3}{3}=11$. It exceeds the rest of the species by 8 molars in both jaws, as *M.* (*Triloph.*) *angustidens* exceeds *M.* (*Triloph.*) *Ohioticus*. A longitudinal belt of enamel has not yet been observed on the tusk of any Elephant. The molars are presented under two forms: in the subgenus *Stegodon* as "Dentes complicati," resembling those of *Mastodon* in the folded form of their crown-eminences, and as "Dentes lamellosi" in *Loxodon* and *Euelephas*. The convexity of the crown-ridges, and the absence of the longitudinal mesial bipartient cleft, so characteristic of the true Mastodons, are very constant in the Elephants, the only exception, limited to the latter character, being indistinctly seen in an *E.* (*Stegod.*) *Cliftii*. The passage from the Stegodons into the Loxodons is effected through *E.* (*Steg.*) *insignis* and *E.* (*Loxod.*) *planifrons*; and from the Loxodons into *Euelephas* through *E.* (*Lox.*) *meridionalis* and *E.* (*Euel.*) *Hysudricus*. The anisomerous ridge-formula in *Euelephas* is not numerically the same in all the species, being in some higher, in others lower: but they all agree in exhibiting progressive increments. The amount of undulation presented by the worn edges of the enamel-plates furnishes a good means of distinguishing the nearly allied fossil species in *Euelephas*.

The distinctive and specific characters of Mastodon and Elephas.—A safe criterion by which to test the soundness of any proposed

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arrangement in Natural History is, that the technical characters, however abridged, should be exponents, so to speak, of the natural and serial affinities, and in nowise at variance with them. If this test be applied to the ridge-formula, as a consistent basis for the arrangement of the Mastodons and Elephants, it will, we believe, not be found wanting: thus the Mastodons ranged under *Trilophodon* and *Tetralophodon* include all the Elephantoid species which have the crowns of the molars comparatively simple, and uniformly divided into two subequal divisions by a longitudinal line or cleft; the ridges limited in number, each with fewer mammillary eminences, and invariably more or less concave across; the enamel thick and in conical or compressed points; and the valleys between the ridges deep and empty, or with but a sparing quantity of cement. The Elephants, on the other hand, as restricted by the ridge-formula and ranged under *Stegodon, Loxodon,* and *Euelephas,* include all the Proboscidean species which have the crowns of the molars more complex, and usually wanting in a longitudinal line of division; the ridges more numerous and less definite, each being composed of a greater number of mammillary or digital points, which are most elevated in the middle, rendering the ridges convex across, instead of concave; the processes of enamel thinner, higher, and more divided; and the deep narrow valleys between them entirely filled up with cement. The limitations of the two genera agree pretty well with the views generally entertained by palæontologists regarding them; with the exception, that the group comprising the collective *Mastodon Elephantoides* of Clift, and by some called *transitional Mastodon**, is here regarded as more properly belonging to the Elephants.

A Synoptical Table is appended of the species of *Mastodon* and *Elephas,* ranged under subgenera, after the manner here indicated. The species were first determined or adopted after a careful examination of all the original materials accessible, in the foreign collections already referred to (p. 309) or in various museums in the United Kingdom. They were then arranged serially, according to their relative affinities, as indicated by the molar teeth; the common characters were next analysed, to furnish a key for breaking up the mass of species into groups representing genera and subgenera; and the synoptical table shows the result. It is put forward as exhibiting a fair representation of the subject so far as the materials and state of knowledge at the present time admit, but with no pretension to being either unexceptionable or complete. The progress of investigation, by the discovery either of new forms, or of more abundant materials of the species which are now the most imperfectly determined, will in all probability modify more or less, or break down, any generic or subgeneric limitations that may be at present devised. For the daily experience of every department of Mammalian palæontology tends to show, that, while the characters of species are persistent over wide areas and through long periods of time, genera are nothing more than ideal or conventional centres, around which groups of species are arranged, subject to incessant modifications through the discovery

* Owen, 'Odontography,' p. 624.

Genera, Subgenera, and Species.					Geological Age.	Country.	Remarks.
MASTODON	Subgen. 1. TRILOPHODON	(*a.*) Colliculi acuti valliculæque transversi	Spec. 1. M. (Trilophodon)	Borsoni (*I. Hays*)	Pliocene	France; Piedmont	Syn. *Mastodon Buffonis* (Pomel).
			„ 2. M. (Triloph.)	tapiroides (*Cuv.*)	Upper Miocene	France; Switzerland	Syn. *Mastodon Turicensis* (Schinz, juxta Von Meyer).
			„ 3. M. (Triloph.)	Ohioticus (*Blumb.*)	Post-Pliocene	North America	Syn. *Mastodon maximus* (Cuv.); *M. giganteus* (Auctorum).
		(*b.*) Colliculi obtusi alternatim mammillati, valliculæ interruptæ.	„ 4. M. (Triloph.)	angustidens (*Cuv.*)	Upper Miocene	France; Germany; Switzerland	Syn. *Mastodon Simorrense* (Lart.); *M. Cuvieri* (Pomel).
			„ 5. M. (Triloph.)	Pyrenaicus (*Lart. MSS.*)	Upper Miocene	France.	
			„ 6. M. (Triloph.)	Humboldtii (*Cuv.*)	Post-Pliocene?	South America	An Syn. *M. australis* of Owen (?); of reputed Australian origin!
			„ 7. M. (Triloph.)	Pandionis	Pliocene?	Southern India	Imperfectly known, but very distinct as a species; is the only Indian *Trilophodon*.
	Subgen. 2. TETRALOPHODON	(*c.*) Colliculi obtusi valliculæque transversi	„ 8. M. (Tetralophodon)	longirostris (*Kaup*)	Upper Miocene	Germany: Eppelsheim.	
			„ 9. M. (Tetraloph.)	latidens (*Clift*)	Miocene	Southern India: Ava.	
		(*d.*) Colliculi obtusi alternatim mammillati, valliculæ interruptæ.	„ 10. M. (Tetraloph.?)	Andium (*Cuv.*)	Pliocene?	South America	Large inferior incisors, one or two. The subgenus doubtful.
			„ 11. M. (Tetraloph.)	Perimensis	Miocene	Southern and Western India	Hitherto fouud only in Perim Island.
			„ 12. M. (Tetraloph.)	Arvernensis (*Croizet & Jobert*)	Pliocene	England; France; Italy	Syn. *Mastodon brevirostre* (Gervais).
		(*e.*) Colliculi numero 5, obtusi alternatim mammillati, valliculæ interruptæ.	„ 13. M. (Tetraloph.)	Sivalensis	Miocene	India: Sewalik Hills	The only known species indicating a Pentalophodou-type.
ELEPHAS	Subgen. 1. STEGODON	(*a.*) Colliculi circiter 6, cæmento in valliculis parco	Spec. 1. E. (Stegodon)	Cliftii	Miocene	Southern India: Ava	Syn. *Mastodon latidens* (Clift, pro parte).
		(*b.*) Colliculi 7–8, cæmento in valliculis copiosissimo	„ 2. E. (Stegod.)	bombifrons	Miocene	India: Sewalik Hills.	
			„ ?3. E. (Stegod.)	? Ganesa	Miocene	India: Sewalik Hills	Distinctness as a species doubtful.
			„ 4. E. (Stegod.)	insignis	Miocene and Pliocene	Sewalik Hills and Central India	Found both in the valley of the Nerbudda (*Pliocene*), and Sewalik Hills (*Miocene*).
	Subgen. 2. LOXODON	(*c.*) Colliculi grossè digitati, adamante crasso	„ 5. E. (Loxodon)	planifrons	Miocene	India: Sewalik Hills	The only Elephant in which premolars have been met with.
			„ 6. E. (Loxod.)	meridionalis (*Nesti*)	Pliocene	England; France; Italy.	
		(*d.*) Colliculi medio angulatim dilatati, machæridibus per detritionem rhomboideis.	„ 7. E. (Loxod.)	priscus (*Goldf.*)	Pliocene	England; Lombardy	Imperfectly known. Fossil remains rare.
			„ 8. E. (Loxod.)	Africanus (*Blumb.*)	Existing	Africa.	
	Subgen. 3. EUELEPHAS	(*e.*) Colliculi subremoti, adamante crassiusculo	„ 9. E. (Euelephas)	Hysudricus	Miocene	India: Sewalik Hills.	
		(*f.*) Colliculi approximati medio leviter dilatati, machæridibus undulatis.	„ 10. E. (Eueleph.)	antiquus	Pliocene	England; France; Italy.	
			„ 11. E. (Eueleph.)	Namadicus	Pliocene	Central India	Restricted to the *Pliocene* Fauna of the valley of Nerbudda, Central India.
		(*g.*) Colliculi approximati, machæridibus valde undulatis.	„ 12. E. (Eueleph.)	Columbi	Post-Pliocene?	Mexico; Georgia; Alabama	An Syn. *E. Jacksoni*? (Sillim. Journ. 1838, vol. xxxiv. p. 363).
			„ 13. E. (Eueleph.)	Indicus (*Linn.*)	Existing	India	Syu. *E. Sumatranus* (Temminck).
			„ 14. E. (Eueleph.)	Armeniacus	?	Armenia: Erzeroom	In the Brit. Mus. Coll. Discovered between Erzeroom and Moosh in 1856. The molar plates closely approximated, and the enamel-edges very undulated.
		(*h.*) Colliculi confertissimi, adamante valde attenuato, machæridibus vix undulatis.	„ 15. E. (Eueleph.)	primigenius (*Blumb.*)	Post-Pliocene	Europe, Asia, and North America.	

of new forms. It would be foreign to the main object of the present communication, and beyond the limits within which it is necessarily restricted, to discuss in detail the grounds on which the arrangement is founded. As this will be done more fully elsewhere, I shall content myself here with stating them in a general way, and with indicating where the assailable points are. Although the Mastodon of North America and the Mammoth are so widely different in the form of their molar teeth that they must be ranked under distinct genera, the intermediate gradations are so complete as to establish a passage from the one into the other. Failing the characters of premolars and inferior incisors, previously relied upon, as distinctive of the Mastodons, and abundant cement as distinctive of the Elephants, the constancy of the ridge-formula in being isomerous, whether ternary, quaternary, or quinary in the intermediate molars, appeared to furnish a sufficient technical demarcation between *Mastodon* and *Elephas*, and to subdivide the former satisfactorily into the natural subgeneric groups of *Trilophodon* and *Tetralophodon*. It remains to be seen whether there is any intermediate species in which the characters of these two groups are blended.

Mastodon Sivalensis is regarded as having five ridges to the "intermediate molars," instead of four; but this remarkable character, being restricted at present to a single species, it was deemed inexpedient to form a systematic section for it alone; and it is ranged at the end of the Tetralophodons.

Although a mesial, bipartient, longitudinal cleft along the summit of the crown is very common in the molars of most of the species of Mastodon, and usually absent in the Elephants, there is one species of the former, *M.* (*Triloph.*) *Borsoni*, in which the cleft is so obsolete, that Isaac Hays* founded the specific character upon the supposed absence of this cleft. But the cleft, although but slightly pronounced, is distinctly present in unworn germ-teeth of this form; and it is even visible in the original molar described by Abbé Borson, upon which Dr. Hays relied for its absence.

The plurality of the species in the first subgeneric group of *Elephas*, namely *Stegodon*, are sufficiently distinguished from the Mastodons by the higher numerical expression of the crown-formula, in showing 7 or 8 ridges instead of 3 or 4; by the great quantity of laminated cement which fills the transverse valleys; by the ridges being convex as in the typical Elephants; by the greater number of points to each ridge; and by the absence of a mesial dividing furrow. But in one of the species, *E.* (*Stegodon*) *Cliftii*, there is an obsolete indication of this furrow; and its affinity to the Mastodon is further evinced by the low or senary expression of the ridge-formula. This species constitutes a frontier form, through which the passage between the two genera is effected; but the details of the other dental characters show that it is most nearly allied to the Stegodons, and the characters of the subgeneric group were constructed to admit of its reception among them. Two of the Loxodons, namely *E.* (*Lox.*) *planifrons* and *E.* (*Lox.*) *Africanus*, have a ridge-

* Transactions of the American Philosophical Society, ser. 2, vol. iv. p. 334.

formula which is identical or nearly so with that of *Stegodon insignis*; but the separation of the group is indicated by the great increase of vertical height in the colliculi, and by the layers of enamel assuming the character of plates, instead of the mastoid eminences of *Stegodon*. *E.* (*Lox.*) *meridionalis* has a higher number of plates in the "intermediate molars" than those two species, and constitutes a frontier form, leading towards the next group, *Euelephas*. But the ridge-formula in this form would appear to be hypisomerous, and the aggregate characters indicate its position among the Loxodons. The majority of the species in the group *Euelephas* are well marked by the progressive increments and high numerical expression of the crown-ridges of the intermediate molars, by the great vertical height of the colliculi, and the attenuated plates of enamel. One species among them, *E.* (*Eueleph.*) *Hysudricus*, constitutes a frontier form leading towards *E.* (*Lox.*) *meridionalis*. More ample details respecting the Elephants will be given in the Second Part of this memoir, when treating of the European fossil species.

To revert specially to the Mastodons, *Trilophodon* and *Tetralophodon* (including under the latter the exceptional five-ridged *Mastodon Sivalensis*), as regards the number of forms at present known, are of nearly equal value, the former in our view comprising 7, and the latter 6, well-marked species; and they are each divisible into two parallel subordinate groups, the exact appreciation of the characters of which is of much service in the determination of the European fossil species. In the one series, the ridges are broad, transverse, more or less compressed into an edge, with the valleys open throughout and uninterrupted by subordinate tubercles: these are well represented in *Trilophodon* by *M.* (*Triloph.*) *Ohioticus*, and in *Tetralophodon* by *M.* (*Tetral.*) *latidens*. In the other series, the ridges are composed of blunt conical points, which are fewer in number, more elevated, and flanked in front and behind by one or more subordinate outlying tubercles, which disturb the transverse direction of the ridges, and block up the valleys, interrupting their continuity across. This series is represented in *Trilophodon* by the Miocene European species *M.* (*Triloph.*) *angustidens*, and in *Tetralophodon* by the Pliocene *M.* (*Tetraloph.*) *Arvernensis* of the Crag (See Plates XI. & XII.). The species with transverse, compressed ridges, in both subgenera, may be compared with *Dinotherium*, as regards their molar crowns; and the other series with *Hippopotamus*.

The European fossil species of *Mastodon* at present known are the following*,—all of which are of Miocene age, with the exception

* M. Aymard has added largely to the nomenclature of the Proboscidea by creating a new genus, and new species for the remains found in the Velay and Auvergne, viz.: *Anancus macroplus*, as a generic form distinct from Mastodon; and *M. Vellavus* and *M. Vialettii*, regarded by Pomel as synonyms of *M. Borsoni*; also a fossil Elephant, *E. giganteus*, Aym. But the specific distinction of these nominal species is exceedingly doubtful (*vide* Bulletin de la Société Géologique; and Congrès Scientifique de France, 1855, p. 276). The species referred to in a preceding page as having been made out by M. Lartet has not yet been published.

of *M.* (*Trilophodon*) *Borsoni* and *M.* (*Tetralophodon*) *Arvernensis*, which are Pliocene.

M. (Triloph.) Borsoni, *Isaac Hays* (Pliocene).
M. (Triloph.) tapiroides, *Cuvier*.
M. (Triloph.) angustidens, *Cuvier*, pro parte.
M. (Tetraloph.) longirostris, *Kaup*.
M. (Tetraloph.) Arvernensis, *Croizet & Jobert* (Pliocene).

The British fossil Mastodon, and its comparison with M. angustidens, M. Arvernensis, and M. longirostris.—The remains of only one species of *Mastodon* have hitherto been discovered in the British Isles, in what is called the Older Pliocene "Red Crag," at Felixstow and Sutton in Suffolk, and in the Newer Pliocene, "Fluvio-marine," or "Mammaliferous Crag" in various localities near Norwich and in Suffolk. I shall now endeavour to ascertain what this species is; and, as I consider that the question is one of considerable importance, as a turning-point upon which the independent character of the British Pliocene fauna hangs,—that is to say, whether it is distinct or merely a long-lived offset from the Miocene,—I shall not hesitate to enter at length upon the details calculated to throw light upon the subject.

Professor Owen is the only English palæontologist who has undertaken to identify and describe in connexion all the Mastodon-remains of the Crag, which he has done very fully in his valuable work 'On the British Fossil Mammalia,' published in 1846. He there designates the species *Mastodon angustidens* or *Mastodonte à dents étroites* of Cuvier; and gives as synonyms, in his opinion, *M. Arvernensis* of Croizet and Jobert, and *M. longirostris* of Kaup. He heads the chapter with a woodcut of the upper and lower jaws of the Eppelsheim *M. longirostris*, after Kaup, under the name of *Mastodon angustidens*; and in his description of the dentition of *M. angustidens* in the 'Odontography *,' he draws his details of the various teeth indifferently from the three nominal species above mentioned, namely, *M. angustidens, M. longirostris,* and *M. Arvernensis*. In his memoir on the Crag Mammalia, contained in the 47th number of the 'Quarterly Journal,' published in August of the present year, he reiterates the opinion that *Mastodon angustidens* and *Mastodon longirostris* are synonyms of the English Crag species. Any opinion emanating from so distinguished a palæontologist as Professor Owen, and repeated by him after mature study, at various intervals, between 1843 and 1856, must necessarily carry great weight with it. The first point, therefore, to determine is, what is the species to which Cuvier's name of *M. angustidens* is legitimately applicable.

(*Mastodon angustidens.*)—The fluviatile or lacustrine Molasse of the basin of the Sub-Pyrenees has from a very remote time been worked, at Simorre, by mines for what was called the "*Turquoise de nouvelle Roche,*" this substance being the ivory of Mastodon-tusks chiefly highly injected with a metallic infiltration, so as to

* *Op. cit.* p. 619 *et seq.*

simulate the natural mineral Turquoise*. The excavations brought to light the numerous Miocene remains found in this rich depôt, and among others the molars of Mastodon. These were vaguely referred to by the old naturalists, under the name of the "Animal de Simorre†." Some of them found their way, in the progress of time, to the Museum of Natural History in Paris, about the middle of the last century, and Daubenton described them under the title of "petrified teeth having relations to those of Hippopotamus," to which indeed in some important respects they bear a very striking analogy. Cuvier, having established his "grand Mastodonte" of North America, next directed his attention to the European remains of the genus, the first of which he published under the title of 'Mastodonte à dents étroites' or *M. angustidens*. It has been proved upon the clearest evidence, by various palæontologists, and admitted among others by his devoted friend and follower Laurillard‡, that Cuvier has included more than one species under this nominal designation of *M. angustidens*. It is requisite therefore to ascertain precisely what were the original types which suggested a name of such palpable signification to a shrewd and philosophical observer like Cuvier. On referring to his original memoir, it will be found that Cuvier commences§, as his first illustration, with a description of one of the Simorre molars previously described by Daubenton. The second piece is the Dax specimen from near Sort, Département des Landes, and obtained from a fluvio-marine Molasse formation probably of the same age as the Simorre lacustrine beds. The third specimen is a South American fragment, brought to Europe by Humboldt, which has no connexion with the European species: on this head all later palæontologists who have investigated the subject, without exception (exclusive of mere compilers), are agreed; among others, Laurillard‖, who identifies it with *M. Andium*, as restricted by him. The fourth specimen which Cuvier quotes is another Simorre fossil. The sixth, a very important and characteristic specimen, is from the same locality. Now, all these Simorre specimens, with the exception of the third, which is a premolar—and therefore a normal exception,—are characterized by having their crowns divided into three principal ridges. "It is therefore," as we have elsewhere¶ stated, "to a species having the intermediate molars distinguished by a ternary division of the crown, as in *M. Ohioticus*, that the specific name of *M. angustidens* is strictly applicable, so far as priority of description and reference to original types can be taken as the guides to a decision on the point." See Plate XI. figs. 3 & 4.

Since the time of Cuvier, Simorre and Sansan have become classical palæontological ground through the important discoveries,

* Reaumur, Mém. de l'Acad. des Sciences, 1715, p. 174; and Lartet, Quelques Aperçus Géologiques dans le Département du Gers," p. 19.

† Id. *op. cit.* p. 24.

‡ Dictionnaire Universel d'Histoire Naturelle, tom. viii. pp. 29–30.

§ Annales du Muséum, tom. viii. p. 412.

‖ Dictionnaire Universel d'Histoire Naturelle, tom. viii. p. 29.

¶ Fauna Antiqua Sivalensis, par. i. 1846, p. 57.

made by M. Lartet, of the first announced fossil monkey in Europe, of *Macrotherium*, *Anisodon*, &c. Among others, a vast quantity of Mastodon-remains have been met with, including the whole dentition, from the young sucking-calf up to the adult and old animals. A superb skeleton was disinterred by Laurillard at Seissan, so complete in every respect, that it has been set up in the Paris Museum, alongside of the skeletons of the existing Indian and African Elephants. Two points which have been invariably exhibited by all these teeth are of special importance in their bearing upon the present question; the first is, that the intermediate molars are constantly three-ridged, or, in other words, belong to the *Trilophodon* type; no *Tetralophodon* molars having ever, within the knowledge of M. Lartet, been discovered either at Simorre, Sansan, or Lombez: the second is, that they entirely agree with the original Simorre types described by Cuvier, upon which his *M. angustidens* is founded; and that they are absolutely the narrowest of all known Mastodon-molars. Another remarkable character of the species is this, that, in harmony with the narrow teeth, the horizontal ramus of the lower jaw is more compressed, and higher in relation to the width, than in any other known Mastodon. This is well shown in the Paris skeleton, and in numerous lower jaws contained in the palæontological gallery. M. Lartet possesses, in his rich collection at Seissan, several lower jaws exhibiting the same character. A nearly entire skeleton of this species was discovered in the latter part of 1855, in the sandstone-quarry of Veltheim, near Winterthur in Canton Zurich; this I was enabled to examine minutely through the kindness of M. Ziegler-Ernst of Winterthur. It is the largest specimen of the species that I have anywhere seen. The lower jaw, although in fragments, is nearly complete, and shows the extreme compression of the horizontal ramus, and its great depth. I found, by measurement with the callipers, that this compression was even greater than is seen in *Dinotherium*, while the lower jaws of most of the known Mastodons and Elephants yield more or less of a circular section. This tenuity of form is carried on throughout the skeleton in the Mastodon of Simorre.

From these remarks it would appear sufficiently evident, that, whether we are guided by priority of description and reference to the original specimens, or by the obvious signification of the term, the title of *Mastodon angustidens* is legitimately applicable to the *Trilophodon* of Simorre, and to no other species: for it is, *par excellence*, the "Mastodonte à dents étroites" of Cuvier. The species, thus limited, has nowhere been met with in the fossil state in England.

(*Mastodon Arvernensis and M. longirostris.*)—But Cuvier, as already stated, included under this name of *M. angustidens* other remains which do not belong to it. Upon this head nearly all the French palæontologists are agreed, although at variance as to the details. Of the specimens figured in the four plates devoted to "Divers Mastodontes" in the 'Ossemens Fossiles,' all those from South America, amounting to 10 in number, are by common consent referred to one or two species peculiar to that country. Seven are referable to the Mastodon of Simorre with narrow molars; one to *M. tapiroides*; five are doubtful, either from inexact knowledge as to their origin, or from their undecided character; and all the rest, being 11 in the aggregate, are from Italy, with the exception of one specimen from Trevoux in France. It is curious to observe the different views that have been taken of them. De Blainville * limits the South American remains to a single species, while Laurillard and Gervais range them under two well-defined forms. De Blainville and Owen agree with Cuvier in referring the so-called narrow-toothed remains from Simorre, Italy, Auvergne, and Eppelsheim also, to a single species. Laurillard, devoted as he was to the traditions of his great leader, was compelled by the evidence to admit two species, namely *M. angustidens*, under which title he included the Italian, Auvergne, and part of the Eppelsheim remains,—and *M. longirostris*, under which he ranged both the principal part of Kaup's Eppelsheim species, and the whole of the Simorre remains †. Misled by the undue importance which he attached to the presence of mandibular incisors common to the two forms, he sunk the characters presented by the molars, and confounded ternary-ridged and quaternary-ridged forms under the same name, although it is distinctly evident that he was aware that two of the European species severally possessed 3 and 4 ridges to their intermediate molars, and that the ternary formula was common to the Mastodons of North America and of Simorre. In 1828, four years before the demise of Cuvier, Croizet and Jobert ‡ proposed the name of *M. Arvernensis* for the Auvergne remains, as distinct from *M. angustidens*, and soon afterwards Dr. Kaup § published his magnificent series of the Eppelsheim form as equally distinct, under the designation of *M. longirostris*, which has been regarded by Herman von Meyer to be identical with *M. Arvernensis* ‖. Lartet ¶ had accurately determined the milk- and permanent dentition (so far as the true molars are concerned) of the Simorre form as far back as 1847. He assigned three ridges to the last milk-molar and to the ante-penultimate and penultimate true molars in both jaws, and in his 'Notice,' ** published in 1851, he proposes to distinguish it by the name of *Mastodon Simorrense*, retaining the designation of *Mastodon angustidens* for the Italian and Auvergne remains, characterized by four ridges in the penultimate true molar, instead of three. Lartet at the same time †† proposed the name of *Mastodon Gaujaci* for a supposed small form from the same Miocene deposit at Lombez. Laurillard considered it as furnishing a confirmation of the conjectural species named *Mastodon minutus* by Cuvier ‡‡.

Gervais followed Laurillard in considering the Simorre *M.* (*Triloph.*) *angustidens* and *M.* (*Tetraloph.*) *longirostris* as be-

* Ostéographie: Des Eléphants.

† Dictionnaire Universel d'Histoire Naturelle, tom. viii. p. 29.

‡ Recherches sur les Ossements fossiles du Département du Puy-de-Dôme, p. 133.

§ Ossements Fossiles de Darmstadt, part iv.

‖ Nova Acta Acad. Nat. Cur. vol. xvii. p. 113.

¶ Dictionnaire Universelle d'Histoire Naturelle, tom. viii. p. 29.

** Notice sur la Colline de Sansan, p. 24.

†† *Op. cit.* p. 27.

‡‡ Dictionnaire Universel d'Histoire Naturelle, tom. viii. p. 31.

longing to the same species, *Mast. longirostris*; but adopted for the Auvergne form the name of *M. Arvernensis*; and went a step beyond his predecessors in proposing a new name for the Mastodon-remains found in the arenaceous deposits near Montpellier, which he identifies with the Mastodon of the Astesan and the Val d'Arno under the name of *M. brevirostre**. Pomel, in his memoir of 1848, proposes a new name for the Simorre *Trilophodon*, namely *M. Cuvieri*, and he retains that of *M. angustidens* for the Auvergne and Italian forms, admitting their distinctness from *M. longirostris* of Eppelsheim †. In his 'Catalogue Méthodique' of 1854 he adopts the name of *M. Arvernensis* for the Auvergne and Montpellier form, to which he assigns the additional foreign localities of the Val d'Arno, Piedmont, and the Crag in England: but in a remark on the next page he reiterates the view expressed in his previous memoir, that he has retained the name of *M. angustidens* for the species of Italy ‡. Nesti §, in his description of the Tuscan remains, adopts the name of *M. angustidens* (Mastodonte a denti stretti) in the loose comprehensive sense in which it was used by Cuvier; while Eugenio Sismonda, aware of the various and contradictory opinions upon the point, guardedly described the fine skeleton found at Dusino in Piedmont, under the title of 'Osteographia di un Mastodonte angustidente' ‖. My friend and collaborateur Colonel Sir Proby Cautley, in 1836, figured and described some teeth of the Indian species to which we subsequently restricted the name of *M.* (*Tetralophodon*) *Sivalensis*, as identical with the "Mastodonte à dents étroites" of Cuvier, and he expressed at the same time the opinion that the Italian form which he had more particularly in view would, with the Sewalik one, constitute a subgenus of the *Angustidens* type, in contradistinction to the type of Clift's *M. latidens* ¶.

These, so far as I am aware, are the leading opinions which have been put forward by original writers on this much-disputed question. Those which have been expressed by the compilers of systematic works on Palæontology, however useful, are of little weight in the discussion, as they express more the balance of the authorities numerically, than opinions formed upon independent examination of the subject by themselves. The specific name *Mastodon angustidens* is even struck out of the list of European species, except as a synonym, in the last edition of Bronn's "Lethæa," and replaced by the terms *M. Arvernensis*, *M. longirostris*, and *M. Cuvieri* **. Palæontologists would confer a great boon on Geology, if they could be brought to agree in applying this name (*M. angustidens*) to the Simorre form, for which it was devised by Cuvier.

The views which we entertain were partially disclosed in the first

* Annales des Sciences Naturelles, 3me série, tom. v. p. 268.
† Bull. de la Soc. Géologique, 1848, tom. v. p. 257.
‡ Catal. méthod. et descript. pp. 74, 75.
§ Nuovo Giorn. de Letterat., Pisa, tom. xii. pp. 17–34.
‖ Mem. del Reale Accad. di Torino, 1851, pp. 175–235.
¶ Journ. of the Asiat. Soc. of Bengal, vol. v. p. 294.
** Lethæa Geognostica, 3rd edit. vol. iii. pp. 827–832 (1856).

part of the letter-press of the 'Fauna Antiqua Sivalensis,' and fully elucidated in the four plates of outline-heads, from Plate 42 to 45, of Part 5 of the illustrations, where a synopsis is given of all the species, fossil and recent, then known. The forms included under the nominal species of *M. angustidens* of Cuvier are there ranged as distinct species, namely

M. (Triloph.) angustidens,
M. (Triloph.) Andium,
M. (Tetraloph.) longirostris,
M. (Tetraloph.) Arvernensis.

The only change which subsequent investigation on fresh materials has led us to make, is to transfer *M. Andium* from the subgenus *Trilophodon* into that of *Tetralophodon*, for reasons which it is not necessary to detail on the present occasion. Of these forms the only one which I believe has been met with in the fossil state in England is *M.* (*Tetralophodon*) *Arvernensis* (Pl. XII.) ; and I shall now proceed to the consideration of the evidence in support of this conclusion.

(*British specimens of Mastodon.*)—Remains of two out of the three species of *Mastodon* with which we are chiefly concerned now, viz. *M.* (*Trilophodon*) *angustidens*, *M.* (*Tetralophodon*) *longirostris*, and *M.* (*Tetralophodon*) *Arvernensis*, have been discovered on the Continent, in the localities where they prevail, in such a perfect condition, that very little remains to be desired in regard to their entire osteology. The skeleton of *M.* (*Trilophodon*) *angustidens* from Seissan, set up in the gallery of Comparative Anatomy in Paris, is so complete in every respect, from the cranium down to the digital phalanges, that it may be compared bone for bone, throughout the frame, with the skeletons of the African and Indian Elephants which adjoin it. Of *M.* (*Tetraloph.*) *Arvernensis*, a nearly entire skeleton was disclosed by a railway-excavation at Dusino near Asti in Piedmont, and is now deposited in the Turin Museum. It is deficient only in the cranial portion of the head, right hind leg, part of the scapula and pelvis, and some of the bones of the carpus and tarsus. The upper and lower jaws, with the tusks entire to their tips, are preserved ; and Prof. Sismonda was only deterred by the brittle condition of the bones, from attempting to reconstruct the whole. A skeleton of the same species nearly as perfect, which I have examined, was discovered in the lower Val d'Arno in a marine stratum, along with the skeleton of a Whale. It is now laid out in the museum at Florence, together with numerous other bones of the same species. From the Miocene sands of Eppelsheim, Kaup disinterred the upper and lower jaws, with an immense quantity of molars, showing the entire dental series, milk and adult, besides various other portions of the skeleton, of *M.* (*Tetralophodon*) *longirostris*. The materials are therefore so abundant now, that it is in a measure easy to institute a comparison more or less rigorous between the three species.

But as regards the English remains of Mastodon, it is quite the reverse. Only solitary teeth detached from the jaws, or part of a mutilated young cranium, have hitherto been described, and the teeth in most cases mutilated. The beautiful vignette which heads the chapter upon *Mastodon angustidens* in the 'British Fossil Mammalia' would convey a very exaggerated notion of the English remains as they are ordinarily met with, but that the author takes care to apprise his readers that it is derived from Kaup's figure of the Eppelsheim species. No good specimen of the lower jaw, so far as I am aware, has yet been found in Britain; nor have any of the large bones of the extremities been identified, although it is more than probable that such do exist in the numerous collections which have been formed in Norfolk and Suffolk. The pieces are usually more or less mutilated; and it is clear that the bones have been broken up before the fragments were deposited in the strata where they are now found. Nothing approaching the remains of a perfect skeleton has been seen in any one locality, with the exception of the notable case recorded by the Rev. J. Layton, in which the entire skeleton of a Mastodon is stated to have been found lying on its side stretched out between the chalk and gravel, at Horstead near Norwich, on a bed of marl. The bones in this instance were heedlessly broken up by the workmen, or dispersed before any steps could be taken for their preservation*.

The molars or other fragments occur scattered and detached. Prof. Owen mentions a well-preserved atlas of apparently *Mastodon angustidens* as being preserved in the Ipswich Museum†. Mastodon molars have been found both in the Red Crag of Suffolk and in the Fluvio-marine Crag of Norfolk and Suffolk; in the former at Sutton and Felixstow, in the latter at Postwick, Whitlingham, Thorpe, Horstead, and Bramerton near Norwich, and at Easton near Southwold. Mr. Charlesworth, in reference to their supposed rarity, mentions, that within the twelve months preceding September 1851, upwards of a dozen of Mastodon molars had been discovered, in washing the Crag to get out the phosphatic nodules ‡. Prof. Owen notices their occurrence in the Crag-pits of Suffolk §. I am not aware that they have yet been discovered in the Fluvio-marine Crag of Bridlington in Yorkshire, nor in any of the freshwater deposits below the Drift, where remains of Elephant and Hippopotamus are more or less abundant.

It is no part of the object of this communication to describe the numerous remains of Mastodon from the Crag, that are to be met with in different English collections. All that is intended, is to determine what the species really is, and only such characteristic specimens will be referred to as exist either in original or as casts in public museums, or as have been so accurately figured and described in works of authority as to be susceptible of satisfactory identification.

First as regards the *Molars*.—The most perfect specimen that has yet been discovered, is the famous Whitlingham tooth, which forms the frontispiece of Mr. W. Smith's 'Strata Identified,' and of which (reversed) a beautiful woodcut is given in fig. 97 of the 'British Fossil Mammalia.' It is also very carefully represented, unreversed, both as regards the plan and profile views of the crown,

* Fairholme's 'Geology of the Scriptures,' p. 281.

† Quart. Journ. Geol. Soc. vol. xii. p. 223.

‡ Warren, 'On *Mastodon giganteus*,' 2nd edit. p. 204.

§ *Op. cit.* p. 223.

in the 'Fauna Antiqua Sivalensis,' pl. 36. figs. 8 and 8*a*. It is the last true molar (upper jaw, right side), being composed of five ridges, with an anterior "talon," and a strong back "talon." The crown is obscurely divided longitudinally by a shallow cleft along its axis. Each ridge consists of about two pairs of thick, high, conical mammillæ, with very thick enamel. Deep clefts or valleys intervene between these ridges; but the valleys, instead of being transverse, are interrupted in the middle by one or more large accessory conical mammillæ, which are interposed between the ridges, and alternate with the outer and inner divisions. These mammillæ are usually connected with the inner division of each ridge in the upper jaw, and with the outer in the lower. They are much thicker than in the other species of Mastodon which possess them, and have a large conical core of ivory. The consequence of this complex composition of the crown is, that, when the ridges have been worn down by continued grinding, they present a great number of distinct *alternate* trefoil discs, surrounded by a ring or belt of enamel, instead of the single or double transverse disc exhibited by the Mastodon of Eppelsheim, *M.* (*Tetralophodon*) *longirostris*, or by the *M.* (*Trilophodon*) *angustidens* of Simorre. In the Eppelsheim species, of which I have carefully examined all the molars contained in the rich collection at Darmstadt, there is a considerable range of variety as regards the accessory tubercles which flank the main ridges. In some of the last molars, the main ridges are perfectly free from any outlying or flanking mammillæ; they are regularly transverse, and the valleys between are equally transverse, and open throughout. In others, the ridges bear numerous small warty tubercles of enamel, which jut into the valleys and distort them. But the transverse continuity of the valleys is never blocked up by the large conical mastoid mammillæ which in the molars of *M.* (*Tetralophodon*) *Arvernensis* invariably alternate with the main ridges, and reduce the valleys to disconnected gorges, occupying the outer and inner sides of the crown. The accessory tubercles in the Eppelsheim species are so unimportant, that their only effect, after advanced wear, is to expand the diameter of the disc, or communicate to it something of a trefoil pattern. The discs are always transverse, while in the English Crag Mastodon they are invariably more or less alternate. In illustration of this very obvious differential character in *M.* (*Tetralophodon*) *longirostris*, the beautiful series of figures given by Kaup in the 'Ossements Fossiles de Darmstadt,' from plates 16 to 21 inclusive, may be quoted; but I would more especially refer to figs. 4 and 5 of pl. 16, figs. 1, 3, 4, and 9 of pl. 18, and figs. 2, 6, and 7 of pl. 21.

We have endeavoured to exhibit these differences in a well-marked and obvious manner, by contrasted figures (drawn with the greatest care and fidelity by Mr. George Ford) of the same tooth in three species, placed side by side, in pl. 36 of the 'Fauna Antiqua Sivalensis.' Figs. 6 and 6 *a* represent in plan and profile the last molar (upper jaw, left side) of *M.* (*Tetralophodon*) *Sivalensis*, an Indian fossil species, which is the most nearly allied to the English Crag

Mastodon so far as the alternate disposition of the crown-mammillæ is concerned, but differing in the ridge-formula. Figs. 8 and 9 represent two specimens of the same tooth of *M.* (*Tetralophodon*) *Arvernensis*, the one being Mr. William Smith's Whitlingham fossil, and the other, fig. 9, Captain Alexander's specimen, dredged up between Southwold and Easton, of which there is a cast in the Geological Society's Museum. Figs. 12 and 13 represent two specimens, of different races or sexes, of the same tooth of *M.* (*Tetralophodon*) *longirostris*, from Eppelsheim. The Sewalik molar, fig. 6, exhibits six ridges and a hind "talon"; the Crag and Eppelsheim molars show only five ridges and the "talon." In the Eppelsheim teeth, figs. 12 and 13, the crown is broad, the mammillæ are thicker in proportion to their height, the ridges are less elevated, and consist of a greater number of coronal points (there being often as many as six or seven to each ridge), the outer and inner lines of points converge less towards the apex of the crown as they rise upwards, and the valleys are either entirely open and transverse, or interrupted only by an insignificant amount of warty tubercles. In the Crag fossils, figs. 8 and 9, the crown is narrower in proportion, the mammillæ form more attenuated cones, and are more elevated; the ridges consist of fewer coronal points, which, instead of running across in a wide crest, appear, so to speak, as if they had been squeezed together, and their transversality disturbed; the outer and inner lines of points, especially the latter, converge rapidly as they ascend, rendering the apex of the crown much narrower than the base; the outer and inner divisions of the crown are more or less alternate, and the vallicular mammillæ that flank and alternate with them are large conical points, which yield discs of wear approaching in size to those of the principal points; the valleys are completely obstructed by these mammillæ, and reduced to a gorge on either side of them. When the teeth are viewed in profile, such as fig. 8, on the above-mentioned plate, compared with fig. 13, the difference is very marked, the latter yielding a series of salient and re-entering angles, corresponding with the prominent points and valleys, which the former does not, the re-entering angles being intercepted by a dark shade, which represents the accessory mammillæ. If the eye is next directed to figs. 6 and 6*a*, the differences are still more marked, *M.* (*Tetralophodon*) *Sivalensis* exhibiting a greater amount of alternation of the crown-mammillæ, and more complexity of pattern, than is even seen in the English Crag Mastodon. To summarize the distinctive characters of the two European species, it may be stated, that *M.* (*Tetr.*) *Arvernensis* (Pl. XII.), with *M.* (*Tetr.*) *Sivalensis*, resemble the Hippopotamoid type, and *M.* (*Tetr.*) *longirostris* (Pl. XI. fig. 1), with the Indian species *M.* (*Tetr.*) *latidens*, the Dinotherian type, in so far as the form of the crowns of the molar teeth is concerned.

Of the last true molar of the lower jaw no good entire specimen, so far as I am aware, has yet been published as having been yielded by the English Crag. But in the Museum of the Geological Society there is a cast of a very fine specimen of this tooth from the left side of the lower jaw, which, according to the label on the cast, was found in the Crag of Suffolk (see Plate XII. figs. 3, 4). It is a nearly unworn germ, measuring about 8½ inches long, by 3 in width in front; without fangs; and the anterior ridge alone being slightly touched by wear. It is composed of five ridges and a talon of two mammillæ. The anterior ridge shows two pairs of mammillæ; the next four ridges present only two large conical mammillæ each, which converge rapidly towards the summit of the crown, and are disposed in an alternate manner. One or more large accessory mammillæ are interposed between the ridges, blocking up valleys in the manner described as characteristic of the species, and the ridges are inclined with a slope which increases successively backwards. The talon appears to have been composed of a pair of points, one of which is mutilated on the inner side, and a small portion of the back end of the tooth is wanting. The slope of the posterior ridges is so pronounced as to approach nearly to the character of "imbrication." In this respect the specimen closely resembles the Val d'Arno molar figured by Cuvier (Divers Mastodontes, pl. 4. f. 7), which he describes as the last of the upper jaw*; but it would seem, from the form and contour, to be an entire germ of the last inferior molar, and, in our opinion, of the same species as the Crag Mastodon, namely *M.* (*Tetraloph.*) *Arvernensis*.

A fragment composing the posterior half of the last inferior true molar has been noticed and figured by Mr. S. Woodward†. It is composed of seven prominent conical mammillæ, disposed in three ridges, which contract very much behind, and terminate in an odd talon-tubercle. These tubercles form two lines, an outer and inner, and they are placed in regular alternation with each other. A corresponding fragment, of which there is a cast in the Geological Society's Museum, is represented by pl. 37. f. 9 & 9[a] of the 'Fauna Antiqua Sivalensis.' The mammillæ, in this case also, form two alternate rows, each ridge being composed of a pair of points.

The finest detached specimen of the Crag species that I have anywhere seen is a last lower molar, left side, found below the citadel of Montpellier, and which has been figured and described by Gervais ‡. Casts of this piece are to be met with in many of the principal European Museums. It is of large size, being about 9½ inches long by 3¼ wide at its anterior end, and consists of five principal ridges and a double talon. The five anterior ridges are well-worn, and exhibit the characteristic alternation of the discs in a very prominent manner, nothing approaching which has ever been seen in an Eppelsheim specimen. M. Gervais refers this tooth to his *Mastodon brevirostris*, as distinguished from *Mastodon Arvernensis*; but the grounds upon which he has attempted this separation are wholly insufficient.

The same peculiar characters in the alternate disposition of the

* Oss. Foss. 4to edit. tom. i. p. 258.

† Mag. of Nat. Hist. 1836, vol. ix. p. 152, fig. 22.

‡ Annales des Sciences Naturelles., 3me sér. t. v. p. 268, and Paléontol. Française, p. 38, tab. 3. fig. 7.

mammillæ of the crown are finely exhibited in the last lower molar of the nearly allied Indian *M.* (*Tetraloph.*) *Sivalensis*, as represented in pl. 37. f. 8 & 8ª of the 'Fauna Antiqua.' The specimens resemble each other so closely, that my colleague Sir Proby Cautley *, in his earliest description, considered them to be identical species.

If, on the other hand, we examine the equivalent teeth in the lower jaw of *M.* (*Tetralophodon*) *longirostris* of Eppelsheim, the same differences as occur in the upper molars are constantly presented. The ridges are transverse, and the coronal eminences in a greater number than a pair of mammillæ, which latter, on the outer and inner sides, are opposed, and not alternate. Figs. 1, 2, & 3 of pl. 19. of Kaup's 'Ossements Fossiles' furnish excellent illustrations.

When these molars, upper and lower, are ground down by well-advanced use, the alternation of the discs in the one species, and their transversality in the other, become still more conspicuous. The former character is exhibited in a very marked manner by figs. 1, 3, & 6 of Cuvier's pl. 4 of "Divers Mastodontes," above referred to. All the specimens are of Italian origin, being either from the Val d'Arno or from the plains of Lombardy and Liguria. Cuvier remarks upon one of them † (f. 6), that it is "remarquable par des festons plus nombreux que dans les autres." They are all referable to *M.* (*Tetralophodon*) *Arvernensis*. The alternate disposition of the discs of wear is also seen well in the specimens of *M.* (*Tetraloph.*) *Arvernensis* discovered in the Artesan near Dusino, and figured and described by Sismonda ‡; while the transverse discs of the Eppelsheim species are more or less apparent throughout Kaup's Illustrations, and more especially in figs. 4 & 5 of pl. 16, figs. 1, 2, 3, & 5 of pl. 19, and figs. 2 & 6 of pl. 21 of his work above quoted.

Of the other true molars, *i. e.* the antepenultimate and penultimate, various specimens, more or less perfect, have been yielded by the Crag. Several existed in Mr. Robert Fitch's interesting collection at Norwich when I examined it in 1846, and probably a considerable addition has been made to it since. Two of these are figured in the 'British Fossil Mammalia' (pp. 280, 281). Fig. 98 is described by Professor Owen as the penultimate upper. The anterior portion is broken off; what remains of the crown shows four ridges and a talon. But for the position assigned to it by so able and practised a palæontologist, the figure would convey the impression of its being a lower instead of an upper molar, from the narrowness of the crown in comparison with the width, and from the form of the hind talon. Fig. 99 represents a corresponding penultimate lower molar, also from Mr. Fitch's collection. Both teeth—the one of which has the crown represented in plan, the other in profile—show in a strongly marked manner the characteristic alternation of the mammillæ, which is never seen in the corresponding molars of the Eppelsheim

* Journ. Asiat. Society of Beng. vol. v. p. 294.

† Oss. Fossiles, 4to edit. tom. i. p. 259.

‡ Osteograph. di un Mastodonte angustidente, tab. 1. figs. 2, 3 (Mem. R. Accad. Sc. Torino. sér. 2. vol. xii.).

species. Moreover, the mammillæ are more elevated, their conical isolation more defined, and the enamel-layer thicker than in *M.* (*Tetraloph.*) *longirostris*. There is a peculiar wavy and finely grooved rugosity of surface, which is seen on the enamel near the base of the crown and "bourrelet" where it exists in the molars of the Crag Mastodon (see Pl. XI. fig. 4) and of the nearly allied Indian species *M.* (*Tetralophodon*) *Sivalensis*. It may be compared to the appearance yielded by a bound book when the edges of the leaves slightly overlap, and they are bent in a flexuous curve. This peculiar rugosity is not nearly so conspicuous in the Eppelsheim species, nor in the *M.* (*Trilophodon*) *angustidens* of Simorre.

The finest English specimen of one of the "intermediate molars" of the Crag Mastodon that has come under my observation is a germ of the penultimate true molar (upper jaw, right side), lately discovered by the Rev. Mr. Marsden in the bed of coprolitic or phosphatic nodules in the parish of Ramsey in Essex, about three miles west of Harwich, and kindly lent to us for description. It is represented (one-third of the natural size) by figs. 1 & 2, Pl. XII. of the accompanying illustrations. It consists of the shell of the crown quite entire, the nucleus of the ivory core not having become fully calcified, nor any of the fangs developed. The crown presents four intact ridges, with a front and a back talon. The mammillæ of the outer and inner lines are very high, and converge as they ascend, so that the apex of the crown is much narrower than the base. Two large outlying mammillæ are interposed between the first and second ridges; one between the second and third, and one between the third and fourth. A large tubercle, flanking the inner division of the first ridge, forms the commencement of the anterior talon. The posterior talon consists of a line of about six low tubercles. The intermediate flanking mammillæ, as is usual in the species, interrupt the transverse continuity of the valleys, which are reduced to an outer and inner gorge. It is manifest that, if the crown were ground down by wear, the disposition of the tubercles is such that a series of trefoil discs, more or less alternate, would be the result. The dimensions of this specimen are—length 4·9 inches, width of crown in front 2·6 inches, width at the last ridge 2·9 inches.

Premolars.—That vertically successional teeth replace one or more of the milk-molars in *M.* (*Tetraloph.*) *Arvernensis*, has been proved by the original specimens from Auvergne, upon which the species was founded by Croizet and Jobert. Fig. 7 of pl. 11 of their work * exhibits an upper jaw of a very young animal, containing the antepenultimate and penultimate milk-molars *in situ*, the former consisting of two pairs of points, disposed in two ridges, the latter showing three ridges. Behind the second tooth there is introduced, in the figure above referred to, a germ-fragment consisting of two ridges (marked A), as if of the third milk-molar; but Abbé Croizet states, in the descriptive details, that the fragment was found detached, and that for various reasons, which are detailed, he considers it to be incorrectly placed in the figure. In the original specimen, which I

* Oss. Fossiles du Départ. du Puy-de-Dôme, pp. 134, 135.

had an opportunity of examining at Paris, the remains of part of the alveolus of a vertical premolar were distinctly visible above the penultimate milk-molar; and M. Laurillard informed me that he had seen the germ of this premolar, the tooth "A" above referred to being the one in question, *i. e.* the penultimate premolar. The last premolar, which is the vertical successor of the last milk-molar, has not as yet been observed *in situ*, so far as I have had the means of ascertaining.

No premolars of the Crag Mastodon, from English localities, have either been figured or described in the 'British Fossil Mammalia,' or elsewhere, up to the present time. This is of little moment, in so far as the mere identification of the species is concerned. Premolar specimens may probably be found either in Mr. Fitch's * or in some other of the Norfolk collections.

Milk-molars.—Of the milk-series it is not necessary on the present occasion to enter on many details. I will refer only to one or two characteristic specimens. The most perfect and instructive yet met with was discovered in the Crag at Postwick by Mr. Wigham, to whom I was indebted for the means of comparing it carefully with a corresponding specimen of *M.* (*Tetraloph.*) *longirostris* from Eppelsheim, belonging to the Earl of Enniskillen. It consists of the left upper jaw of a calf Crag Mastodon, with the last milk-molar beautifully preserved *in situ*, and the remains of the empty alveolus of the penultimate milk-molar in front of it. The tooth is stated, in Sir Charles Lyell's memoir on the "Relative Ages of the Tertiary Deposits of Norfolk †," to be the "second true molar." But it is really the last milk-molar. He adds:—"This fragment was sufficiently perfect to enable Mr. Owen, to whom I submitted it, to refer it to *Mastodon longirostris*, a species also found at Eppelsheim." The crown measures 3 inches long by 1·8 inch broad, and is composed of four ridges, with a front and hind talon, and a well-pronounced basal "bourrelet." The three anterior ridges are more or less worn, especially along the inner division; the last ridge is nearly intact. Two views of this tooth, drawn with the utmost care by an artist of well-known power and fidelity, Mr. George Ford, are shown in the 'Fauna Antiqua Sivalensis,' pl. 36. f. 7 & 7^a. The ridges are seen to be connected by one or two stout conical mammillæ, which occupy the middle of the valleys, interrupting their transverse continuity, and alternating with the divisions of the main ridges, in the manner characteristic of the older or true molars previously described. If these figures are compared with figs. 6 & 6^a of the same work, by the same artist, which represent Lord Enniskillen's very beautiful specimen of the young calf Mastodon from Eppelsheim, the distinctive characters of the two species will be found to be carried on throughout. The Eppelsheim specimen is a little younger than the Crag fragment; it shows the series of three milk-molars *in situ*. The third milk-molar is nearly intact; the

* The specimen referred to by Mr. Fitch, as cited in the 'British Fossil Mammalia,' p. 290, is not a premolar of the Crag Mastodon.

† Mag. of Nat. Hist. 1839, p. 318.

four ridges of which it is composed are seen to be transverse, compressed, and composed of a number of little points; the valleys are open, with the exception of a tubercle in the first and two or three minute tubercles in the last valley, which nowise intercept their transverse continuity. The back talon forms a low transverse free ridgelet, as in *M.* (*Tetralophodon*) *latidens* of India; while in *M.* (*Tetralophodon*) *Arvernensis* the talon-tubercles are huddled together and accrete to the last ridge.

Sir Charles Lyell, in his 'Manual*,' gives a figure of Mr. Wigham's tooth of the natural size, in which a very notable character of the young molars is well brought out. The enamel of the mammillæ is seen to be furrowed vertically by numerous deep parallel grooves, presenting the appearance of a reeded column or of a number of cords pressed close together, and disposed around a thick central axis. The shell of enamel shows as if it were composed of distinct narrow pieces glued together. The same character is attempted to be represented by *b* & *c* of fig. 7, pl. 36. of the 'Fauna Antiq. Siv.,' also of the natural size. It does not occur in the corresponding young molars of *M.* (*Tetralophodon*) *longirostris*. The enamel-surface in these is superficially wrinkled and furrowed with numerous irregularities, without however exhibiting the symmetrical fluting observable in the Crag Mastodon. So conspicuous is this character, that I believe that the young teeth of the two species could be distinguished from each other by portions of their enamel alone, occurring mixed in a collection. I would refer to a figure given by Kaup of the dentition of a young *Mastodon longirostris* in pl. 16. f. 1 of his 'Ossements Fossiles,' for the comparison. It is of the natural size, and the last milk-molar may be contrasted with the corresponding tooth of the Crag species figured by Sir Charles Lyell. It was this character in the young teeth which chiefly led Croizet and Jobert †, in 1828, to propose *Mastodon Arvernensis* as a distinct species. They met with specimens in Auvergne, mostly of very young animals, of both the upper and lower jaws, in which the last milk-molar was unworn, and they were struck with the remarkable complexity of the crown-ridges, composed of a great number of small wart-like cones, separated by the decurrent vertical grooves, which we have referred to. But the indicated character was not accepted by Cuvier as of sufficient importance to distinguish the species from his too comprehensive *Mastodon angustidens*.

Another fine specimen of the last upper milk-molar, from Mr. Fitch's collection, is figured in the 'British Fossil Mammalia' (fig. 100, p. 284). Like Mr. Wigham's specimen, the crown is composed of four ridges and a talon, with the same complexity of pattern, alternation of the flanking tubercles, and interruption of the valleys. It is only necessary to cite it here, as proving the constancy of the characters of the Crag specimens. Prof. Owen describes this tooth as the "fourth upper molar;" while he assigns a different

* Manual of Element. Geol. 5th edit. 1855, p. 166, fig. 133.

† Croizet et Jobert, Oss. Foss. du Départ. du Puy-de-Dôme, 1828, p. 133.

position and value to Mr. Wigham's specimen, considering the latter to be the "second true molar." In our view they are both last milk-molars, which would be the equivalent of what Prof. Owen designates as "the fourth in the order of size, and the third in the order of position, counting backwards in the upper jaw, before any of the teeth are shed *."

There is some intricacy in the terms expressive of the numerical values which Prof. Owen assigns to the different molars of Mastodon in his descriptions, both in the 'British Fossil Mammalia,' and in the 'Odontography.' This, I believe, has arisen from the peculiar views there advanced, as to the order of succession of the premolar teeth in this genus; and, as it is a point of systematic and palæontological importance in reference to the disputed affinities between *Mastodon* and *Dinotherium*, I think it desirable to make a few remarks on the subject. In both the works here cited †, it is affirmed that Mastodon is distinguished from Elephant, in a well-marked and unequivocal manner, by two dental characters: the first is the presence of tusks in the lower jaw; the second "is the displacement of the first and second molars" (meaning milk-molars) "in the vertical direction by a tooth of simpler form than the second, a true *dent de remplacement*, developed above the deciduous teeth in the upper, and below them in the under jaw." Prof. Owen, in his remarks upon Mr. Fitch's specimen of the last milk-molar (fig. 100), goes on to say, "In Dr. Kaup's figure the tooth in question" (*i. e.* the third) "is associated with the first and second molars of the *Mastodon angustidens*, which are much worn, and are true deciduous teeth, the only ones, in fact, which strictly correspond with the deciduous teeth of ordinary Pachyderms ‡." In this view, when the ante-penultimate and penultimate milk-molars are shed, and the penultimate premolar has made its appearance, he designates the latter as the "third molar tooth;" and the last milk-molar, which is behind it in position, but anterior in appearance, he calls the "fourth molar tooth," although fully aware that there were good grounds for regarding it "as the last of the theoretically deciduous series, although it has no vertical successor." But this conclusion as to the absence of a vertical successor to the tooth in question was premature; I detected both the penultimate and last premolars *in situ* in the jaws of *E.* (*Loxodon*) *planifrons*, a Sewalik fossil Elephant, upwards of twelve years ago. The evidence is published in the 'Fauna Antiqua Sivalensis' §. M. Lartet has found the same two premolars repeatedly in the upper and lower jaws of *M.* (*Trilophodon*) *angustidens* ||. In a manuscript note appended to the work here quoted, with which I have been favoured by M. Lartet, he adds, "J'ai pu depuis lors vérifier plusieurs fois le remplacement effectif de la 2[me] et de la 3[me] molaire de lait, tant à la machoire supérieure qu'à

* *Loc. cit.*
† Brit. Foss. Mamm. p. 274, and Odontography, p. 615.
‡ Brit. Foss. Mamm. p. 284.
§ *Op. cit.* p. 31, pl. 6. f. 4–6; pl. 12. f. 8–11.
|| Lartet, Notice sur la Colline de Sansan, 1851, p. 25.

l'inférieure comme cela a lieu dans le Dinotherium ; la première n'est jamais remplacée." In a beautiful specimen of the lower jaw of a young *M.* (*Trilophodon*) *angustidens*, belonging to M. Ziegler-Ernst of Winterthur, I found both the penultimate and last premolars present, the former protruded, the latter in germ. When a single premolar is developed, it is the successor to the last milk-molar, and not to the penultimate, as stated by Prof. Owen in the passages above referred to *. I have seen detached specimens of this last premolar, both of the upper and lower jaws of *M.* (*Tetralophodon*) *longirostris* of Eppelsheim, in the Museum at Darmstadt. The order of succession here indicated is alone consistent with what occurs in other Pachyderms, where, when suppression in either of the milk- or premolar series takes place, it is constantly the anterior or feebly developed and rudimentary teeth that are suppressed. In them we never find the last premolar suppressed while the penultimate is developed, but the reverse. The penultimate premolar replaces only the corresponding milk-molar: the ante-penultimate milk-tooth is never replaced in *Mastodon* or *Elephas*, so far as observation has yet shown. The molar dentition of the permanent or second set (*i. e.* the premolars and true molars) in *M.* (*Triloph.*) *angustidens* and *Dinotherium* is numerically identical, consisting of two premolars and three true molars ; each of these having also two well-developed mandibular tusks : and the close affinity thus indicated by the number of teeth is further borne out by the correspondence of a ternary-ridged formula in two of their "intermediate molars," and by other osteological characters †, which leave little room for doubt that they were both Proboscidean genera, *Dinotherium* having close affinities to the Tapirs, as Cuvier sagaciously inferred in his earliest memoir on 'Les Tapirs Gigantesques ‡.'

Of the ante-penultimate and penultimate milk-molars no speci-

* In his subsequent memoir on the molar teeth of *Phacochœrus*, &c. (Phil. Trans. 1850, p. 496), Professor Owen takes a different view of the premolar teeth in *Mastodon* from that set forth in the 'British Fossil Mammalia' and the 'Odontography.' It is expressed thus :—" The existing species of the gigantic Proboscidian family, viz. the Asiatic and African Elephants, are totally devoid of incisors on the lower jaw, and all their grinding teeth succeed each other horizontally ; so that it is only by a more than proportional increase of size that the ante-penultimate grinder is recognizable as the first of the true molar series, and the antecedent smaller grinders, as the homologues of the milk-molars of other Diphyodonts, which milk-molars have no successors in the Elephants. In certain Mastodons, however, which are the earliest known forms of the Proboscidian family, the last milk-molar was displaced by a vertical successor or premolar." The tooth, which, in his earliest descriptions, was considered as the successor of the ante-penultimate and penultimate (first and second) milk-molars, is here regarded as the successor of the last milk-molar. But the presence of both the penultimate and last premolars in *Mastodon angustidens* is not recognized.

† In M. Ziegler-Ernst's Winterthur specimen of the young lower jaw above referred to, five molar teeth are present, viz. the penultimate and last premolars—the former extruded, the latter imbedded ; the last milk-molar far advanced in wear, and immediately over the last premolar ; and the ante-penultimate and penultimate true molars both in germ, but the former partially emerged and in incipient use.

‡ Annales du Muséum, tom. iii. p. 132.

mens from the Crag have been as yet figured or described; but the characters presented by these teeth in *M. (Tetraloph.) Arvernensis* are well known, both in the upper and lower jaws, through the specimens discovered by Croizet and Jobert, Bravard, and others in Auvergne or the Velay. The ante-penultimate presents two ridges, and the penultimate three ridges, with the usual talon-complications. They are readily distinguishable—the upper from the lower—when met with detached, from the circumstance that the milk-molars of the lower jaw are narrower and more compressed, the ante-penultimate being reduced to a single cusp. Figures of these teeth are given by Croizet and Jobert in the work already referred to*.

The ridge-formula in the molar teeth of the Crag Mastodon, including milk- and true molars, but exclusive of premolars, as inferred from the various data detailed in the previous pages, is—

$$\overbrace{\frac{2+3+4}{2+3+4}}^{\text{Milk-molars.}} \; : \; \overbrace{\frac{4+4+5}{4+4+5}}^{\text{True molars.}}$$

The assigned numbers have not been verified in every instance upon Crag remains; but they are all founded on an examination of specimens, of which some were of foreign origin, when materials were not available from the Crag†.

* Oss. Foss. du Puy-de-Dôme, pl. 1. figs. 1–3 and pl. 2. fig. 7.

† In the descriptions of the various teeth throughout this memoir, the terms *ante-penultimate*, *penultimate*, and *last* have been used, instead of the numeral expressions of *first*, *second*, and *third*, when designating the position either of the milk- or of the permanent molars. This would seem indispensable when symbols are not employed, to avoid confusion in the designation of the milk-molars, since the typical *first* or most anterior of the milk-molar series, which is present in many other pachydermatous genera, is constantly suppressed in the Mastodons and generally also in the Elephants. When, therefore, the terms *first*, *second*, and *third* milk-molars are applied to *Mastodon*, they are not the equivalents of the same numerals applied to *Rhinoceros* or *Hippopotamus*, in which all the four milk-molars are developed; whereas the terms *ante-penultimate*, *penultimate*, and *last* in every case represent homologous teeth in the milk-molars of all the ungulate genera. This is the more necessary, as the theoretical *first* or *pre-ante-penultimate* milk-molar is occasionally met with in the African Elephant. De Blainville (Ostéographie: Des Eléphants, tab. ix. p. 81) has given an illustration of its presence in the latter species, on one side of the lower jaw, regarding it as a "supernumerary" tooth; and a corresponding occurrence in the lower jaw of the same species is represented in the 'Fauna Antiqua Sivalensis' (pl. 14. fig. 4 *a*). It is usually restricted to one side; and I regard it as not very uncommon. As the true molars never exceed, nor are below, three in number in the Pachydermata and Ruminantia, the same terms may be conveniently used in describing them. The inconvenience of designating the molars in Mastodon and Elephas by successive numbers ranging from 1 to 6 or 7, which include both milk- and true molars without distinction in the same numerical category, is exhibited in the descriptions of the Elephants given throughout by De Blainville in his 'Ostéographie;' and more recently in the otherwise excellent descriptions by Gervais of the dentition of *Mastodon Andium* in the 'Expédition de Castelnau.' The penultimate and last milk-molars are there figured and described as the "third and fourth" molars, involving a confusion of the ridge-formula, which is seen to be of so much importance in the subgeneric distinctions (Recherches sur les Mammifères Fossiles de l'Amérique Méridionale, 1855, pp. 20–22, pl. 5. figs. 1–5).

Lower jaw.—The characters furnished by the lower jaw are of great significance in distinguishing the nearly allied species of *Mastodon*, more especially in what relates to the form of the symphysis and the presence or absence of mandibular incisors. The differences between the lower jaws of *M.* (*Trilophodon*) *angustidens*, *M.* (*Tetraloph.*) *longirostris*, and *M.* (*Tetraloph.*) *Arvernensis* are so pronounced, that they would have been sufficient to discriminate the species, supposing the molar teeth were unknown to us. As above stated, no good specimen, so far as I am aware, has hitherto been discovered of the lower jaw of the Crag species, *M.* (*Tetr.*) *Arvernensis*, in England; but several have been met with in the Pliocene strata of Italy and France; while abundant remains of the lower jaw of *M.* (*Tetraloph.*) *longirostris* have been disinterred from the Eppelsheim sands by Dr. Kaup; and of *M.* (*Trilophodon*) *angustidens* by MM. Lartet and Laurillard from the Falunian deposits of the Sub-Pyrenees.

First in regard to *M.* (*Triloph.*) *angustidens*. The lower jaw of this species is at once distinguished by the great elongation, downward direction, and slender form of the symphysial portion which contains the sockets of the two inferior incisors*. The ascending ramus is of moderate height, corresponding in that respect with *M.* (*Trilophodon*) *Ohioticus*, and approaching that of *Dinotherium giganteum*. The horizontal ramus is very high in front, in a line with the mentary foramen, and low behind; the anterior portion is compressed; and the lower margin stretches some way in front of the mentary foramen, in a straight line; it is then bent a little downwards, and continued forwards in nearly the same straight line; the under surface of the elongated portion forming an obtuse angle with the corresponding surface of the horizontal ramus. The elongation of the symphysial beak is enormous, far exceeding that of *M.* (*Tetralophodon*) *longirostris*, or even of *Dinotherium*; the length from the mentary foramen forwards being more than double that of the horizontal ramus, measured from the same point backwards to the base of the anterior margin of the coronoid process. A constant character of the species is the presence in both sexes of two long, closely adpressed, and straight, or but slightly curved, incisors. This fact has been established by M. Lartet upon a very large number of specimens†.

These lower incisors differ notably in form from the upper. In the adult specimens they are nearly of uniform diameter from the base to the point, which is bevelled on the upper side by wear, so as to yield a flat or spathulate surface. In section they are pyriform, with frequently a longitudinal channel on the upper and inner side. The section closely approaches that of the inferior canines of the fossil *Hippopotamus* named *Hexaprotodon Sivalensis*. The tusks or upper incisors of this species are nearly circular in section, and taper gradually to a conical point. They are invested along their length on the inner side by a broad band of enamel, which runs in an obsolete

* De Blainville, Ostéographie: Des Eléphants, pl. 14.
† Lartet, Notice sur la Colline de Sansan, p. 24.

spire, so as to be presented on the upper surface near the tip. M. Lartet has never observed any indication of a belt of enamel on the lower incisors. In the superb complete skeleton which was disinterred by Laurillard at Seissan, the extruded portion of these lower incisors measures 20½ inches, that of the upper tusks being 41 inches. The characters above indicated are constant, wherever the lower jaw of this species has been discovered, whether in the Faluns of the Orleannais and Touraine, in the Lacustrine deposits of Gascony and Languedoc, or in the Miocene Molasse of Switzerland, where I found them confirmed by the examination of two very fine specimens, young and old, found in the neighbourhood of Winterthur. They are well shown by the representations given in De Blainville's 'Ostéographie: des Eléphants,' pl. 14. The molar teeth in all these specimens have constantly presented the normal marks of the *Trilophodon*-division, namely three ridges to the last milk-molar, and to the ante-penultimate and penultimate true molars.

In *M.* (*Tetralophodon*) *longirostris* the ascending ramus is considerably more elevated than in *M.* (*Triloph.*) *angustidens*, approaching more the character which is seen in the Elephants proper; the horizontal ramus is less compressed and more circular in section; instead of presenting the greatest height in a line with the commencement of the alveolar border, or mentary foramen, it is contracted there, in consequence of the lower margin rising upwards to slope off into the base of the symphysial beak*. This beak is very massive and comparatively short, not exceeding the length of the horizontal ramus, from the mentary foramen to the anterior margin of the ascending ramus. Instead of being, as it were, a deflected continuation of the inferior border of the jaw, as is seen in *M.* (*Trilophodon*) *angustidens*, the beak in the Eppelsheim species is thrown off in a plane nearly parallel with the inferior border, but separated from it and raised above it by a step. It is deflected slightly downwards; but, instead of forming a long slender apophysis as in the other species, it shows a thick mass traversed by a broad gutter. The greater extent of the beak is made up of the alveoli of two mandibular incisors, as in *M.* (*Trilophodon*) *angustidens*. These teeth have not yet been found *in situ*. Kaup has figured three specimens† which he conjecturally considers to be lower incisors. The greatest diameter of the largest he states to be 2·75 inches. The molars of these Eppelsheim jaws have constantly exhibited the *Tetralophodon*-character of four ridges to the crowns of the intermediate teeth; the ridges being transverse, with the valleys nearly uninterrupted.

In the Pliocene *M.* (*Tetraloph.*) *Arvernensis*, the lower jaw differs widely from that of the other two species. The ascending ramus is well elevated above the grinding-plane of the teeth, as in *M.* (*Tetraloph.*) *longirostris*. The horizontal ramus is very massive, without compression, and yields a section which is nearly circular, as in that

* Kaup, Oss. Foss. de Darmst. tab. 19. fig. 1.
† Ossemens Fossiles de Darmstadt, tab. 3. figs. 1, 2, 3.

species. But the symphysis, instead of being elongated into a process composed of the alveoli of two mandibular incisors, terminates suddenly in a short beak, as in the Elephants and other Proboscidean species that are destitute of inferior tusks. This beak does not project much more beyond the anterior rounded surface of the jaw than in the African Elephant, or in *M.* (*Trilophodon*) *Humboldtii*, also a species without mandibular incisors; but it differs from them and all other known species in the diastemal ridges expanding at the point, so as to form a short, blunt, dilated spout. This character is well shown by the Val d'Arno specimen delineated by Cuvier in the 'Ossemens Fossiles,' tom. i. t. 9. f. 5 & 6, after Nesti. It is one of the pieces upon which Nesti founded his *Elephas meridionalis*; but which, although the molars are wanting, Cuvier sagaciously inferred, from the general form, to belong to a *Mastodon*. I was enabled, by the obliging permission of Professor Gaspero Mazzi, to examine the specimen minutely, and to compare it with the numerous lower jaws of *E.* (*Loxodon*) *meridionalis* and of *M.* (*Tetraloph.*) *Arvernensis* contained in the Natural History Museum at Florence, and was satisfied that it belonged to the latter species, as Cuvier had inferred from the drawing. The same Museum contains the greater part of a skeleton of this Mastodon, found in a marine deposit of the lower Val d'Arno above Leghorn. The lower jaw of this specimen presents the same character of a short symphysial beak without incisors. The same is exhibited by the lower jaw of the Dusino skeleton from the Astesan, described by Prof. Eugenio Sismonda *. They all agree in the common characters, so far as these are shown, of a *Tetralophodon*-formula to the crown-ridges of the three molars here called intermediate; of alternate mammillæ to the ridges, with blocked-up valleys; and of a short obtuse beak with no incisors.

Sismonda describes and figures the lower jaw of the Dusino specimen as being without tusks, or remains of their sockets. But, predisposed to believe that they must have been present at some period of the animal's existence, from their occurrence in other Mastodons, he conjectures that those tusks had fallen out early, and that the alveoli had been obliterated by filling up; and he has given a representation of a very mutilated fragment of a Proboscidean symphysis of the lower jaw, as exhibiting the alveoli of two mandibular incisors †. I was enabled, by the obliging kindness of Signor Bartolomeo Gastaldi of Turin, to examine the specimen in question, which is very much rolled, and in a different mineral condition from the fossils of the Dusino Mastodon-bed, and found that the supposed incisive alveoli were only the anterior terminations of the dentary canals, which are of large size in all the Proboscidea. The form impressed me with the conviction that it was more probably the symphysis of an Elephant than of a Mastodon. This case, therefore, gives no support to the belief that *M.* (*Tetralophodon*) *Arvernensis* had lower incisors.

* Osteograph. di un Mastod. angustidente, tab. 1. fig. 1.

† *Op. cit.* tab. 1. fig. 7.

Professor Owen, in his 'British Fossil Mammalia,' gives a very beautiful representation (p. 291, fig. 101) of a fragment of a tusk discovered by Mr. Fitch in the Mammaliferous Crag-pits near Norwich. He describes it as a portion of the lower tusk of the *Mastodon angustidens*. The specimen is about 15 inches long, with a greatest diameter of 3½ inches. It is of a straight, compressed, conical form. The fragment is crushed, and it is manifest that the outer layers of the ivory are detached, and that the original tusk was of a larger diameter than the specimen now exhibits. The marked conical form and great size are irreconcileable with this fragment being referable to an inferior incisor of the Simorre *M.* (*Triloph.*) *angustidens* of Cuvier: and it would seem to me that it is equally irreconcileable with being considered as a lower tusk of *M.* (*Tetralophodon*) *longirostris*, for the symphysial beak required for the implantation of a tusk of such magnitude would be enormous, and is unknown among any of the species of Mastodon. Professor Owen describes the specimen as being traversed from end to end by a subcentral canal. The same character has been observed in the upper tusks of other fossil Proboscidea, and is nowise characteristic of a lower incisor. I consider that the specimen in question is not a fragment of a lower, but of an upper tusk near the point; and it differs in no important respect from the undoubted upper tusks of *M.* (*Tetralophodon*) *Arvernensis* seen in the Museums of Florence and Turin, which are either slightly curved or twisted in a gentle spiral direction, as represented in the figure given by Sismonda * of the Dusino skeleton.

In corroboration of this view, it may be stated, that the Indian fossil species which we have named *M.* (*Tetralophodon*) *Sivalensis* is in some respects more nearly allied to the Crag species than the latter is to either *M.* (*Trilophodon*) *angustidens* or *M.* (*Tetralophodon*) *longirostris*. It shows the same alternate character of the mammillæ of the ridges of the "intermediate molars," and it appears to have been equally destitute of inferior incisors. I have examined a large number of lower jaws of this species, of all ages, from the sucking calf up to the adult animal, specially with a view to the detection of these teeth, and never observed the slightest indication of their presence in any specimen, whether in the Indian fossil collection of the British Museum, at the India House, or in the rich series belonging to the Asiatic Society of Calcutta.

This completes what I have to bring forward in the shape of descriptive and comparative details, in order to indicate the most prominent diagnostic characters derivable from the teeth and jaws of the Crag Mastodon. I believe that the differences of the three species included by Cuvier under the name of *Mastodon angustidens* will be found to be carried out through all the principal bones of the skeleton. It would be wholly out of place to enter upon such osteographical particulars on the present occasion; but a good idea of

* *Op. cit.* tab. 1. figs. 4 & 5.

the general character of the skeleton in each may be attained by a reference to two well-known standards of comparison, namely, the existing Indian Elephant and the Mastodon of North America, *M.* (*Trilophodon*) *Ohioticus*. Cuvier found that the latter differed from the Elephant in having a more elongated carcass sustained upon shorter, thieker, and more robust legs *. The Crag *M.* (*Tetralophodon*) *Arvernensis* appears to have had a heavy eareass, with legs still shorter in proportion, approaching more the eharaeter of the Hippopotamus, and to have been without lower tusks. The Eppelsheim Miocene species, *M.* (*Tetralophodon*) *longirostris*, would appear to have resembled the Crag species in its general proportions; but the necessary detailed eomparison has not yet been suffieiently carried out; it is distinguished at onee by the possession of inferior tusks. On the other hand, the Mioeene *M.* (*Trilophodon*) *angustidens* differed remarkably from both, in presenting a eomparatively slender build throughout; so that it stood higher in proportion, and with longer limbs, than either the Indian or Afriean Elephants. This is well exhibited by the mounted skeleton in the Paris Museum.

Geological age of the Mastodons (*M. angustidens, M. longirostris, and M. Arvernensis*).—I shall now eonsider the geological age and assoeiated faunas of the formations in which these speeies severally oeeur.

M. (*Trilophodon*) *angustidens* is a eharacteristic species of the Mioeene Falunian beds throughout Europe. It has been met with in immense abundance in the laeustrine deposits of Gascony and Languedoe; in the Faluns of Touraine and the Orleannais; in the Mioeene Molasse of Switzerland, more espeeially in the lignites of Ellg, Kœpfnaeh and Buchberg, and in the sandstone in the neighbourhood of Winterthur; in the Georgensgmünd Mioeene in Germany; and in the lignite of Gandino in the Val Seriana of Lombardy. The mammalian genera and species with whieh it was associated are very constant, although, for obvious reasons, they have not been found equally or uniformly distributed all over the area. In the Freneh Falunian deposits there oceur *M.* (*Trilophodon*) *tapiroides*, a speeies first conjeeturally named by Cuvier, but subsequently made out well by MM. Pomel, Lartet, and other French palæontologists, *Dinotherium giganteum*, or the smaller variety, as I eonsider it, called *D. Cuvieri, Chalicotherium Goldfussi, Anchitherium Aurelianense, Aceratherium incisivum* (*Rhinoceros tetradactylus*, Lartet), *Aceratherium Goldfussi* (*Rhinoc. brachypus*, Lartet), *Rhinoceros Sansaniensis, Lophiochœrus Blainvillii, Macrotherium giganteum, Dicrocerus* and *Dorcatherium*, &e., besides various Carnivorous forms, large and small, with remains of Chelonian genera, together with scanty indications of Crocodile †.

In the Upper freshwater Molasse of Switzerland *M.* (*Trilophodon*) *angustidens* occurs along with *M.* (*Triloph.*) *tapiroides* (whieh has been named *Mastodon Turicensis*, as a distinct species, by Schinz

* Oss. Foss. 4to edit. tom. i. p. 249.

† Lartet, Notice sur la Colline de Sansın.

and Von Meyer), *Aceratherium incisivum*, *Acerather. Goldfussi*, *Dinotherium giganteum*, *Lophiochœrus Blainvillii*, a species of *Tapir*, *Palæomeryx* and other Ruminants, &c., with several species of Chelonians.

M. (*Tetralophodon*) *longirostris* occurs abundantly in the sands of Eppelsheim, associated with *Dinotherium giganteum*, *Chalicotherium Goldfussi*, *Rhinoceros Schleiermacheri*, *Aceratherium incisivum*, *Acerath. Goldfussi*, *Macrotherium giganteum*, *Hippotherium gracile*, and species of *Dorcatherium*, *Machairodus*, *Amphicyon*, &c.

The agreement in so many remarkable generic and specific mammalian forms leaves little room for doubt that the Eppelsheim sands and the lacustrine deposits of the Garonne and other parts of France are of the same Miocene age. But there are some notable peculiarities in the Eppelsheim fauna. No well-marked specimen, so far as I am aware, of *M.* (*Tetralophodon*) *longirostris*, as here defined, has hitherto been met with beyond the limited area of the Eppelsheim sands, and probably the valley of the Danube; nor has either *M.* (*Trilophodon*) *angustidens* or *M.* (*Triloph.*) *tapiroides*—which usually go together—been discovered within it. It is very improbable that the range of this species should have been confined to a small district in the valley of the Rhine; but the fact is undoubted, that it occurs there in great abundance, and has either not yet been found, or is very rare, elsewhere. The only exception out of Germany, with which I am acquainted, is a specimen of unknown origin in the Museum of the Faculty of Sciences at Toulouse, which, on the indication of M. Lartet, I was enabled to examine by the kindness of M. Leymerie. It consists of an upper right maxillary containing the penultimate and last molars *in situ*. They present all the characters of *M.* (*Tetralophodon*) *longirostris*, as distinguished from *M.* (*Tetraloph.*) *angustidens*. M. Leymerie informed me that the specimen is supposed to have been found either in Gascony or Languedoc, but that there was no record of the exact locality. It is not improbable that another exception is formed by the specimens mentioned by Cuvier (Oss. Foss. additions, 4to edit. tom. iii. p. 318) as having been discovered by M. Lourteau at Sairac in the Subpyrenees. Two of the molars are described as having the *Tetralophodon*-character of four ridges; but, no figures having been given, the details are not sufficiently precise or exact to admit of any decided opinion upon the subject.

A satisfactory geological limitation of the Eppelsheim deposit and its organic contents is attended with some difficulty. The loose incoherent sand of which it is composed is spread out horizontally like the Löss, and the margin thins out to spread over a portion of the "Lower Miocene" Mayence Basin; so that where the beds are in contact the fossil remains of the two are liable to be confounded. But in all its leading features the Mammalian Fauna of Eppelsheim resembles that of the Falunian deposits of France and Switzerland.

I shall now consider the relations of the Pliocene fauna in which the Crag Mastodon occurs. *M. (Tetraloph.) Arvernensis*, as here defined, had a wide range of habitat in Europe, embracing Italy, France, and England. The principal localities in which it has been found are—in Italy, the Val d'Arno (in great abundance), associated with the Elephant called *E. meridionalis* by Nesti (*Loxod. meridionalis*), *Rhinoceros leptorhinus, Hippopotamus major*, with species of *Tapirus, Sus, Equus, Ursus, Hyæna, Felis, Machairodus*, &c.*; in the marine "Panchina inferiore," of the Lower Val d'Arno, an entire Mastodon skeleton was found along with those of extinct Whales; in Piedmont and Lombardy, in various localities in the Subapennine strata along the Valley of the Po, but more especially in the Astesan, Romagnano, and Duchy of Piacenza, along with the *M.* (*Triloph.*) *Borsoni* (*M. Buffonis* of Pomel), a well-marked ternary-ridged species, first brought to notice by Abbé Borson, and the extinct Elephants *E.* (*Loxod.*) *meridionalis, E.* (*Loxod.*) *priscus*, and *E.* (*Euelephas*) *antiquus*, and *Rhinoc. leptorhinus, Hippopotamus major*, &c. which occur in some places in fluviatile deposits along with species of *Helix, Paludina*, and *Clausilia*, and in others in marine deposits along with sea-shells; in France, in various parts of the southern Departments, in Pliocene strata, such as the marine sands of Montpellier and its vicinity, the valley of the Rhone near Lyons and Trevaux, the Vivarais, Velay, Auvergne, &c.

Great diversity of opinion holds among the French palæontologists as to the association of the mammalian species among which *M.* (*Tetraloph.*) *Arvernensis* occurs in French deposits. I shall refer briefly, on the present occasion, to the disputed cases at Montpellier or its vicinity, and in Auvergne. De Christol† has described the marine sands of Montpellier and the gravel-beds of the contiguous basin of Pézénas as of the same age. From the latter he procured remains of Elephant which he ascribed to the *Eleph. meridionalis* of Nesti, *Hippopotamus major*, two species of *Equus*, one of *Bos*, and two of *Cervus*. Gervais, on the other hand, insists that the gravels of Pézénas are of the age of the Diluvian fauna (Pleistocene), the sands of Montpellier being Pliocene. To the former ‡ he attributes *Elephas primigenius, Hippopotamus major*, two species of *Equus, Bos priscus*, and *Cervus martialis*; and to the latter § *Mastodon brevirostre* (*Tetraloph. Arvernensis*), *Rhinoceros megarhinus, Tapirus minor*, with species of *Sus, Cervus, Ursus, Machairodus, Halitherium, Hoplocetus*, &c. M. Gervais does not admit Elephant-remains in the Pliocene fauna of Montpellier; but there are two circumstances which diminish the authority of this opinion upon the subject,—the first being, that he refers all the fossil elephants found in the south of France to the mammoth, *E. primigenius*, of the Diluvian fauna, of which he considers *E. meridionalis* to be a variety; the second, that he does not admit that any species of fossil Elephant have been discovered anywhere in Pliocene strata in Europe. He considers that

* Savi e Meneghini sulla Geolog. Stratigraph. della Tuscana, p. 508.
† Annales des Scien. Natur. 2 sér. tom. iv. p. 193.
‡ Paléontol. Franç. tom. ii. descript. pl. 21.
§ *Op. cit.* tom. ii. descript. pl. 30.

in the instances asserted by Croizet, Christol, Marcel de Serres, and others, Mastodon bones have been mistaken for those of Elephant*. But, putting aside the disputed French cases, it will be seen in the sequel that there are undoubted instances of the occurrence of remains of Mastodon and Elephant in the same strata in the Subapennine beds of Italy, and in the Crag of Norfolk. In Auvergne and the Velay, the lacustrine and regenerated alluvial strata of all ages, from the Miocene up to the Postpliocene, have undergone such complicated disturbances from successive volcanic eruptions, that great difficulty has been experienced in separating the members of the various faunas, more especially of the subdivisions of the Pliocene and later period. The utmost diversity of opinion holds among the palæontologists who have paid most attention to the later types of the fossil Mammalia of Auvergne, regarding the groups of species which were co-existent at different times. Without going into details, I may observe, that Bravard has endeavoured to make out three distinct faunas after the Miocene lacustrine beds of the Limagne: 1st, a *Mastozoic*, or Pliocene fauna, characterized by the presence of species of *Mastodon* and the absence of Elephants, Horse, and Hippopotamus; 2nd, an *Elephantine* fauna, comprising these genera; and 3rd, a *Diluvian* fauna, in which Elephants and Rhinoceros, &c. are wanting†. Pomel, on the other hand, in his last detailed memoir, has attempted to distinguish after the Miocene lacustrine deposits of the Limagne, 1st, a Pliocene fauna, characterized by two species of Mastodon, a Rhinoceros, Sus, Tapir, and twelve or fourteen species of Cervus, but no Elephants; 2nd, an alluvial fauna, which he divides into two distinct series of different ages: the one more ancient, comprising *Elephas meridionalis*, *Rhinoceros leptorhinus* and *Rhinoc Aymardi*, *Hippopotamus major*, *Tapirus elegans*, *Ursus spelæus*, *Bos priscus*, *Megantereon latidens*, and two species of Deer, &c.; the other, more modern, consisting of *Eleph. primigenius*, *E. priscus*, *Rhinoceros tichorhinus*, *Hyæna spelæa*, *Cervus Guettardi*, &c.‡ But there are grave objections to both these arrangements, inasmuch as the association of the species does not correspond with what holds elsewhere in the Pliocene and Postpliocene deposits of Italy, England, and Germany, which are free from the volcanic intrusions that have overwhelmed and confused the deposits of Auvergne. It suffices for my purpose on the present occasion, to state that, where *M.* (*Tetralophodon*) *Arvernensis* occurs in Auvergne and the Velay, the same species are met with in different localities as are found together in the same Pliocene stratum in the plains of Piedmont and Lombardy, namely, *M.* (*Trilophodon*) *Borsoni*, *Rhinoceros leptorhinus*, *Hippopotamus major*, and the Elephants called *E.* (*Loxodon*) *meridionalis* and *E.* (*Loxodon*) *priscus* (?), with species of *Tapirus*, *Sus*, *Cervus*, &c. The numerical agreement of the Auvergne fossil species with those which occur in the richer fauna of the Val d'Arno is still more

* Gervais, *op. cit.* tom. i. p. 36.

† Bravard, cited by Pomel, 'Bullet. de la Soc. Géolog. de France,' 2 sér. tom. iii. p. 178 *et seq.*

‡ Pomel, *loc. cit.* and Catalog. Méthod. et Descriptif, &c. 1854, pp. 172–184.

considerable. But it is, at the same time, to be remarked, that at the late Meeting of the "Congrès Scientifique" of France, held at Puy in Sept. 1855, MM. Croizet, Aymard, and Pichot* were agreed that the Mastodon-remains in the Velay and Auvergne were of an older age than the beds containing Elephant-remains.

(*Mastodon of the Crag.*)—I shall now pass under review the circumstances under which *M.* (*Tetralophodon*) *Arvernensis* occurs in British strata.

First, in the "Fluvio-marine" or "Norwich Crag." Undoubted remains of this species have been discovered in this deposit: at Whitlingham by Mr. William Smith; at Horstead by Messrs. Layton, S. Woodward, and Gunn; at Postwick, Thorpe, and Norwich by Messrs. Fitch and Wigham; at Bramerton by Mr. S. Woodward and Capt. Alexander; and in Suffolk, at Easton and Sizewell Gap by Capt. Alexander. The entire skeleton, of which so circumstantial an account has been given by the Rev. Mr. Layton, is stated to have been found on the surface of a bed of marl, "between the chalk and gravel," at Horstead, without indicating the precise relation of the bed to the Crag and the superincumbent blue clay or submerged forest-bed. I have examined the most of these specimens, either in original or as casts, at the museums in Norwich and London, and found them all referable to the species, as here limited.

Various statements have been made by different writers regarding the fossil Mammalia associated in the Fluvio-marine Crag, with the *Mastodon* or without it. Mr. William Smith's celebrated Whitlingham specimen is said to have been found along with the horns of Deer, and Crag-shells†. Mr. R. C. Taylor‡ mentions that the Crag of Bramerton has yielded "the Mastodon, the Elephant, the Gigantic Elk and the Enormous-horned Bison." Mr. Charlesworth§ states, that bones of Elephant and other herbivorous animals are more frequently associated with shells in the Mammaliferous than in the Red Crag, but he does not mention what the species are. Sir Charles Lyell‖, in his memoir on the "Relative Ages of the Norfolk and Suffolk Crag," states that the Fluvio-marine Crag, near Southwold, has yielded the remains of the Elephant, Rhinoceros, Horse, and Deer, mixed with marine, terrestrial, and freshwater shells; and that in the inland pits near the same place he found mammalian remains associated with the *Cyrena trigonula* of Grays and elsewhere. He mentions, that "the horns of Stags, bones and teeth of Horse, Pig, Elephant, and other quadrupeds," associated with *Mastodon*, had been obtained at Postwick, Thorpe, Bramerton, and other localities near Norwich. The tusk of an Elephant was obtained at Bramerton, covered with *Serpulæ*, showing that it had lain for some time at the bottom of the sea of the Norwich Crag¶.

* Congrès Scientifique de France, 1855, tom. i. p. 325.
† Taylor, Geology of East Norfolk, 1827, p. 14.
‡ *Loc. cit.* § Phil. Mag. 3rd ser. vol. vii. 1835, p. 89.
‖ Geol. Proc. vol. iii. p. 127; and Mag. Nat. Hist. new ser. vol. iii. p. 316.
¶ *Op. cit.* p. 128.

Professor Owen, in the conspectus of genera and species contained in the introduction to his 'British Fossil Mammalia,' enumerates in the list of the fossils of the Pliocene Fluvio-marine Crag the following genera and species, viz. *Mastodon angustidens*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus fossilis*, *Cervus elaphus*, *Arvicola*, and *Lutra*. But, influenced probably by the opinion at which he had arrived, that the Crag *Mastodon* was identical with the *M. angustidens* of Cuvier and *M. longirostris* of Kaup, he adds, in a note, that all the other species, except *Mastodon*, were probably derived from the overlying blue clay*. The contemporaneous association of these species is unquestionably in the highest degree improbable, as it would include a Miocene Mastodon, along with a Post-pliocene Elephant and Rhinoceros, and the existing Red Deer, in the same fauna. But it admits of no doubt that species of the genera above enumerated have been found in the Fluvio-marine Crag, and it is of importance to ascertain what these species really are. I carefully examined the Elephant-molars from the Crag, blue clay, or submerged forest-bed, contained in the different collections at Norwich, and arrived at the conclusion that none of them belonged to *E. primigenius*, the Mammoth of Siberia, properly so called; but to two distinct species, the one, *E.* (*Loxodon*) *meridionalis*, which occurs in vast abundance in the Val d'Arno; and the other, *E.* (*Euelephas*) *antiquus*, which is found in the plains of the Astesan, in Piedmont, in various other parts of Europe, and in the so-called "Newer Pliocene" freshwater deposits and caves of England. The evidence upon which these species are founded will be considered in the sequel. The occurrence of the Siberian *Rhinoceros tichorhinus* (*Rhin. antiquitatis* of Blumenbach) in the Crag would seem exceedingly improbable; for, elsewhere, it has invariably been met with in company with the Mammoth, in the northern fauna of the Glacial Drift period, and nowhere as yet, upon undoubted evidence, in Pliocene formations. Professor Owen (Brit. Foss. Mamm. p. 381) states, that "Mr. Fitch of Norwich possesses specimens of upper and lower molar teeth of the *Rh. leptorhinus* from the freshwater (lignite) beds on the Norfolk coast near Cromer, which demonstrate the occurrence of this species in the same deposit with the *Rh. tichorhinus*." The contemporaneous association of the two species in these beds would seem as improbable as the occurrence of *Rh. tichorhinus* in the Crag, and the explanation may be sought for in an adventitious mixing of the specimens†. The evidence adduced in support of the existing common Otter (*Lutra vulgaris*‡) and Red Deer (*Cervus elaphus*) having also been found in the same deposit, would require to be very

* *Op. cit.* p. xlvi.

† Mr. Charlesworth, in remarking that the bones of Elephants and other quadrupeds are more frequently associated with the shells of the Crag in Norfolk, adds that, "in that county the formation in many places exhibits such irregularities, and is sometimes so mingled with immense accumulations of sand and gravel, that it becomes almost impossible to distinguish the specific crag-deposit from the accompanying diluvial strata."—Phil. Mag. 3rd ser. vol. vii. p. 89.

‡ Owen, Brit. Foss. Mamm. p. 121.

conclusive before the facts alleged could be received as well-established. For no fewer than eight species of *Cervus*, belonging to the sub-genera *Rusa* and *Strongyloceros*, with round antlers, have been described by the French palæontologists as occurring in the Velay and Auvergne, besides eleven other species in Pliocene or Post-pliocene strata*. Several species with round-antlered horns have also been obtained from the Val d'Arno, which would seem to be identical with Auvergne forms (making liberal allowance for *doubles emplois* in the specific names), and it is much more probable, from the agreement in the other associated mammals, that the Crag species belonged to one of these than to the existing *Cervus elaphus*†. *Hippopotamus major* and *Rhinoceros leptorhinus*, if not hitherto obtained from the Fluvio-marine Crag, occur in abundance either in the blue clay or in the ancient forest or lignite-bed, which immediately overlies the Crag in the sections along the Norfolk coast; and evidence will be adduced in the sequel, that these beds are of the same Pliocene age, in so far as is shown by the paramount proof of identity of mammalian fauna. Taking together the ascertained fossil Mammalia of these two beds, they agree very closely with the Pliocene fauna of the Subapennines, viz. *M.* (*Tetralophodon*) *Arvernensis*, *E.* (*Loxodon*) *meridionalis*, *E.* (*Euelephas*) *antiquus*, *Rhinoceros leptorhinus*, *Hippopotamus major*, large Bovidæ, and large Deer with round-antlered horns. Among the Proboscidean forms the principal exception is the absence of the *Mastodon* here called *M.* (*Trilophodon*) *Borsoni* from the Crag and blue clay. This species, which occurs both in the Astesan and in Auvergne and other parts of France, is so nearly allied to the Mastodon of North America, that the first discovered European specimens were regarded by Cuvier ‡ as belonging to that species; but its specific distinctness has been clearly established by the French palæontologists, and its occurrence in the Crag or overlying beds may yet be expected, if it has not been heretofore overlooked by collectors. The species would seem to be exceedingly rare in Italy, since tooth-specimens referable to it are either unique or nearly so in the public collections there.

Next, as regards the "Red Crag" of Suffolk. Mammalian remains were formerly so rare in the "Red Crag," that their abun-

* Pomel, Catal. Méthod. et Descript. p. 103.

† Gervais has expressed doubts respecting the veritable association of these living with extinct forms:—

"Il est également à supposer, que les nouvelles recherches des géologues d'Angleterre démontreront aux paléontologistes de ce pays que certains animaux reconnus par M. Owen comme étant d'espèces actuelles n'ont pas appartenu, comme ils le supposent, à l'époque pliocène. Tels sont le Cerf, la Loutre, et le Sanglier ordinaires. Le *Rhinoceros tichorhinus*, que nous considérons comme charactéristique du pléistocène, nous paraît aussi devoir être rayé de la liste des animaux pliocènes. On pourrait supposer qu'il s'est glissé quelque erreur dans la détermination des pièces osseuses regardées comme telles, mais cette detérmination est garantie par la citation que M. Owen fait de cette espèce dans sa liste chronologique des Mammifères fossiles en Angleterre, et il est plus probable que c'est sur l'âge du terrain lui-même que l'on s'est trompé."—Gervais, Paléontol. Française, tom. i. p. 180.

‡ Oss. Foss. 4th edit. tom. iii. p. 375.

dance in the Norwich Crag was seized upon by Mr. Charlesworth, as furnishing a significant designation for the latter under the name of "Mammaliferous Crag." But latterly, the excavations for phosphatic nodules have led to the discovery of these remains in abundance. Among others, molars of *M.* (*Tetralophodon*) *Arvernensis* have been obtained in very considerable numbers. By the liberal kindness of Professor Henslow, I have been enabled to examine at leisure those which are contained in the Ipswich Museum, presented to that institution by Mr. George Ransome. They were found in the Red Crag pits. Some of these remains are now on the table before the Society. One, a very characteristic specimen, consists of the greater part of the last true molar, upper jaw, left side. It presents all the distinctive marks of *M.* (*Tetralophodon*) *Arvernensis*, namely, the discs of the worn tubercles decidedly alternate, and the valleys blocked up by large outlying tubercles. These "Red Crag" molars differ in no respect specifically from those found in the Fluvio-marine Crag. They are highly impregnated with ferruginous infiltration, and present a vitreous polish, very much like that of the Mastodon-molars from Perim Island on the western coast of India. They are mutilated by fracture, but do not present the appearance of having been rolled. The fractured edges of the enamel are sharp; and the only indications of abrasion which the teeth present are the natural results of wear, from long service as grinders. This is a point of some importance, as indicative that they were not washed into the Red Crag out of some older Miocene deposit.

Mr. Charlesworth, in his memoir on the "Crag of Suffolk," &c., after enumerating the genera of fossil fish that prevailed in the ocean of the Red Crag, adds—"It is here also that we first meet with the higher orders of the animal kingdom. The teeth of the Mastodon, Elephant, Hippopotamus, and other *Mammalia* are deposited with the *Mollusca* of this period, and in addition to them I may mention the bones of *Birds*, which I have recently obtained from several localities*."

Professor Owen has on three occasions described the fossil mammalia of the Red Crag: first, in 1840†; next, in his 'British Fossil Mammalia' in 1846; and latterly, as a Supplement, in No. 47 of the Quarterly Journal of the Geological Society‡. In neither has he included two of the genera cited by Mr. Charlesworth, viz. *Elephas* and *Hippopotamus*, both being of great significance as diagnostic of the age of European tertiary strata. No specimen of a tooth of *Hippopotamus* from a Red Crag locality, so far as I am aware, has hitherto been figured or described; and the occurrence of this genus in the deposit cannot at present be regarded as an established fact; but several molars of fossil *Elephas*, presenting the characteristic mineral condition of the mammalian remains of the Red Crag, have long been deposited in public and private collections, bearing labels as being from Red Crag localities in Suffolk. One specimen,

* Phil. Mag. 3rd ser. vol. viii. p. 535.
† Ann. & Mag. of Nat. Hist. vol. iv. p. 186.
‡ *Op. cit.* 1856, vol. xii. p. 217.

in particular, in the Museum of Practical Geology, is marked as being from Felixstow, and other reputed instances of the same kind will be noticed in the sequel.

In the "Conspectus" contained in the 'British Fossil Mammalia,' Prof. Owen enumerates, as Mammalia of the "Miocene Red Crag," remains of *Ursus, Meles, Felis pardoides, Sus,* and *Cervus*. But he adds in a note, that "the nature of the stratum renders the actual age of these fossils doubtful." To the enumeration of the five Eocene species of *Cetacea* in the same conspectus, he appends a note, "that most of them occur in the Miocene Crag, but there is little doubt that they were washed out of the underlying Eocene clay." The "Cetotolites" in question were discovered by Professor Henslow in the Red Crag at Felixstow *, which has yielded abundant mammalian remains of herbivorous quadrupeds. In his late paper, Professor Owen gives an account, more or less detailed, of the remains of twelve species of Mammalia (exclusive of *Cetacea*) from the Red Crag, belonging to the genera *Rhinoceros, Tapirus, Sus, Equus* and probably *Hipparion, Mastodon, Cervus* (of the subgenera *Dicranoceros* and *Megaceros*), *Felis* (two species), *Canis,* and *Ursus*. He sums up with the following conclusion, which, from its importance, I quote *in extenso* :—

"From the foregoing details it will be seen that the researches now applied during fifteen years to the mammalian fossils of the Red Crag of Suffolk have led to the very interesting result, that the majority of them are identical, or closely correspond, with miocene forms of Mammalia, and especially with those from the Eppelsheim locality, described by Prof. Kaup. In Suffolk, as in Darmstadt, we find the *Mastodon longirostris, Rhinoceros Schleiermacheri, Tapirus priscus, Sus palæochœrus,* and *Cervus dicranoceros,* associated together in the same formation ; and, with these miocene forms of extinct Mammalia in the Red Crag, we have likewise a Cetacean which most closely resembles a miocene species of that order, previously recognized in the Crag or Molasse of the Continent. At the same time there are, as *e. g.* in the *Megaceros,* specimens of newer pliocene or pleistocene forms of Mammalia mingled with the older tertiary species ; whilst, on the other hand, eocene forms of fish, as *e. g. Edaphodon,* with *Myliobatidæ* and eocene Crustacea, have been obtained from the Red Crag pits.

"As, however, several of the Mammalia which occur in miocene formations are also found in the older pliocene deposits in parts of France, it would be rash, perhaps, to pronounce positively on the miocene age of any of the above-cited crag-fossils ; but it is certain that the majority of those mammalian fossils, and by far the greatest proportion of individual specimens, belong to an older tertiary period than the Mammalia of the newer pliocene drifts, gravels, brick-earths, and bone-caves." (*Loc. cit.* p. 229.)

In this view, regarded in the most restricted sense, a very mixed origin and complex character are attributed to the Mammalian fossils of the Red Crag, and it would seem to be open to several objections,

* Quart. Journ. Geol. Soc. vol. i. p. 37.

some of which I shall now state. Professor Owen, having satisfied himself that the Mastodon of the Crag was identical with the Miocene species of Eppelsheim, was naturally predisposed, where the evidence was at all ambiguous or indecisive, to regard the remains of the other fossil Mammalia with a leaning towards a Miocene origin. First, as regards the *Rhinoceros*; the European fossil species of this genus, including *Acerotherium*, are at present involved in such a maze of confused synonymy that no two living palæontologists are agreed about the number, or upon the names which ought to be applied to them. In consequence, it is exceedingly difficult to arrive at any satisfactory conclusion where a fossil Rhinoceros older than the Siberian species forms an element of the discussion. In the 'British Fossil Mammalia*,' Professor Owen adopts the opinion of Christol, that *Rh. Schleiermacheri* and *Rh. megarhinus* are synonyms of the same species, the former having been founded by Kaup upon Miocene remains discovered at Eppelsheim, the latter by Christol upon Pliocene remains from Montpellier: from his late memoir it would appear that he now considers them distinct, and he leans doubtingly towards the opinion that the Crag molars of this genus, upper and lower, belong to the Miocene *Rhin. Schleiermacheri*, rather than to *Rh. megarhinus*. But without going into details, it may be stated that these teeth present no characters, so far as they have been described, inconsistent with their being referred to the so-called *Rhin. megarhinus* of the South of France and Italy. The premolars possess the basal "bourrelet" which Christol pointed out as one of the distinguishing marks of his *Rhin. megarhinus*: it occurs, as stated by Professor Owen, in the same teeth of *Rhin. Schleiermacheri*, and it is met with also in the premolars of the *Rhin. leptorhinus* of Cuvier. Further, it would seem to be clearly established now, that Cuvier was quite correct in characterizing his *Rhin. leptorhinus* as destitute of a nasal bony septum, and that Christol was misled by the deceptive appearance of a drawing in assigning this peculiarity to the original Italian specimen, and confounding it with *Rhin. tichorhinus*†. There are also the strongest grounds for believing that the *Rhin. megarhinus* of the Pliocene sands of Montpellier is specifically identical with *Rhin. leptorhinus* of Cuvier. The Red Crag specimens, figured and described by Professor Owen, are undoubtedly very like the corresponding teeth of *Rhin. Schleiermacheri*; but it seems to me that the materials are not sufficient to establish a satisfactory palæontological identification, and that it is at present an open question whether they belong to *Rhin. leptorhinus* of Cuvier, or to *Rhin. Schleiermacheri* of Kaup. The same remark applies to the Tapir of

* *Op. cit.* p. 370.

† Cornalia, in Duvernoy's "Nouvelles Études sur les Rhinoc. Fossiles" (Archiv. du Muséum, tom. vii. p. 99). He describes the original specimen, which is deposited in the Natural History Museum at Milan, as perfectly free from any trace of a bony septum, whether along the median line of the nasals, or upon the floor of the nasal cavity. Christol, not having had access to the specimen, misinterpreted a shaded portion of a drawing of it as a representation of the septum. Dr. Cornalia's remarks confirm, in every essential respect, the previous description by Cuvier.

the Red Crag, which Prof. Owen refers, on the evidence of a single upper and single lower molar, to the Miocene *Tapirus priscus* of Kaup. Pliocene species of Tapir have been met with both in Italy and France, one of which has been named *T. Arvernensis* (Croizet and Jobert), and the other *T. elegans** (Pomel); and a supposed third species, *T. minor* of Marcel de Serres, has been yielded by the marine sands of Montpellier†. The adduced evidence would seem hardly sufficient to establish that the Crag molars do not belong to either of these. And so also in regard to the Crag *Suidæ* referred by Professor Owen to the Eppelsheim species, *Sus palæochœrus* and *Sus antiquus* of Kaup. The Crag specimens upon which the identification is founded are limited in each case to a single detached upper molar. The tooth referred by Prof. Owen to *Sus palæochœrus* assuredly bears a very close resemblance to the figure of that of the Eppelsheim species with which he compares it: but the evidence, it must be admitted, is too limited to bear out a satisfactory specific identification; for aught that is shown to the contrary, except a slight difference of size, both of the Crag teeth may belong to the same species. An extinct species of *Sus*, *S. Arvernensis* of Croizet, has been found in the Pliocene strata of Auvergne; another supposed species, *S. provincialis* of Gervais, in the marine Pliocene sands of Montpellier; and species, as yet undetermined, of the same genus, occur in the Pliocene deposits of Italy. Is it certain that the "Red Crag" molars of *Sus* differ from all these?

The *Equus* of the Red Crag is stated by Professor Owen to resemble in the molar teeth his *Equus plicidens* of the Oreston Cavern, reconcileable with a Pliocene origin. The evidence respecting the teeth of the form considered by Prof. Owen "as probably of the subgenus *Hipparion*" has not been adduced. This subgenus had hitherto been regarded as strictly confined to Miocene strata, but Gervais‡ has attempted to distinguish several species from the marl-beds of Curcuron in the Vaucluse, the age of which, whether Miocene or Pliocene, he alleges, still remains to be determined.

As regards the two Cervine Ruminants from the Red Crag, the determination of the form which Prof. Owen refers to *Cervus dicranocerus* of Eppelsheim rests upon two shed antlers and two detached molars. The horns undoubtedly closely resemble those figured by Kaup of that species; but, as Prof. Owen states, a species presenting the rare character of a similar bifurcate form of antler, and named *Cervus australis* by Marcel de Serres§, has been discovered in the Pliocene marine sands of Montpellier; and it has not been shown that the Crag form differs specifically from it. The identification which is most at variance with the conclusions hitherto accepted is that of the shed antler, said to be from a Crag-pit at

* Pomel, Catal. Méthod. et Descript. p. 84.

† Gervais, Paléontol. Française, tom. ii. p. 4. pl. 5. figs. 4 & 5. Gervais doubts, with De Blainville, whether the materials are sufficient at present to prove that these Pliocene nominal species really differ from the *Tapirus priscus* of Eppelsheim.

‡ Paléontol. Française, tom. i. p. 177.

§ Gervais, Paléontol. Française, tom. i. p. 85. pl. 7. figs. 1–3.

Felixstow, which Professor Owen (in the reference to the figure) describes as the "base of the antler of the *Megaceros Hibernicus*;" inferred to occur in a formation where the majority of the mammalian species are regarded as Miocene. Any determination emanating from so distinguished a palæontologist as Professor Owen must be entertained with the respect which his great authority carries with it. But the specimen in question, although (like most of the fossils of the "Red Crag") highly impregnated with iron, and of corresponding gravity, is encrusted with fresh patches of *Lepralia Peachii*. Prof. Busk, to whom I am indebted for this identification, after a careful examination of the original, informs me that the pearly appearance and transparency of the walls of the cells indicate the modern origin of this marine Bryozoon. Other species of the same genus are found in abundance upon the fossil shells of the Red Crag, but they are invariably more or less tinged with an ochreous colour, and the walls of the cells are opaque. Instead, therefore, of having been found in a Crag-pit (the statement under which the specimen came before Professor Owen), it would seem most probable that it was dredged out of the present sea, from some locality off the coasts of Suffolk or Essex. Teeth and bones of Elephants and of other herbivorous mammalia, highly impregnated with iron, and encrusted with marine Bryozoa, are brought up by the dredge, or found upon the beach, at intervals all along the coast from Mundesley to Harwich. A large number of molars of *Elephas* (*Loxod.*) *meridionalis*, presenting a highly vitreous polish, heavy, and dark-coloured, exist in Mr. Fitch's collection at Norwich; and analogous remains are to be met with in various collections in Suffolk and Essex; yet it is not a little remarkable, considering the numerous descriptions of the coast-section which have been made by different English geologists, that the particular beds from which these remains have been derived, have not yet been determined with precision. No authentic case has as yet been made out of remains of the Irish Elk in strata of an older date than the period of the Mammoth, Siberian Rhinoceros, and *Ursus spelæus* of the Glacial fauna: and the palæontological evidence would require to be very conclusive before the range of this species could be extended so as to include the Pliocenes of the Subapennine period.

As regards the Carnivora of the "Red Crag" enumerated by Prof. Owen, the evidence, so far as it has been published, is of a very limited nature, being confined to detached teeth, and is adequate for little more than the identification of the respective genera. No Miocene species of *Ursus* has yet been met with in Europe. The tooth from a Red Crag pit at Newbourn, which Professor Owen guardedly describes as "somewhat smaller than the corresponding tooth of the *Ursus spelæus*," would correspond in size with that of the Pliocene *Ursus Arvernensis*, found abundantly in Italy and Auvergne. Professor Owen admits that the carnassial teeth specimens, from Newbourn and Woodridge, of his *Felis pardoides*, do not differ in size from the Pliocene *Felis pardinensis* of Croizet and Jobert, found in Auvergne, and it remains to be shown that the former is specifically different from the latter form. The remarkable sectorial tooth from the Red Crag, which, according to Professor Owen, closely resembles one of the ancient Carnivora called *Hyænodon* and *Pterodon*, and which he suspects to be an indication of an extinct osculant genus, linking on the true Felines to the Hyæna or Musteline family, has not been generically determined; and it may have been washed in from strata of the Eocene age*.

If, on the other hand, a palæontologist, having satisfied himself that the Red Crag Mastodon is an undoubted Pliocene form, and finding the same species in the Fluvio-marine Crag, were to infer that they were both of the same geological age, and if he were then to take a group of some of the well-established species as a starting-point, he would experience little difficulty in reconciling many of the more doubtful mammalian species with a consistent Pliocene association. The species would run in the following order:—The Proboscidea, *M.* (*Tetralophodon*) *Arvernensis*, *E.* (*Loxodon*) *meridionalis*, and *E.* (*Euelephas*) *antiquus*; the Pachydermata, *Rhinoceros leptorhinus* or *Rhinoc.* —— ?, *Tapirus Arvernensis*, and *Equus plicidens*; the Carnivora, *Felis pardinensis*, *Ursus Arvernensis*, and probably a Pliocene species of *Canis*. With such an harmonious agreement in the great leading forms, he would naturally look to Pliocene forms for comparison when he met with scanty and indecisive remains of such a widely distributed and extensive genus as *Cervus*, unless the characters were so pronounced as to be decisive of species of an earlier age.

This is the manner in which I have been led to regard the fossil Mammalia of the Red and Fluvio-marine Crag; and it has appeared to me that (where remains obviously of an anterior epoch have not been adventitiously intermixed) they agree generally, so far as the species have been well determined, with the great Pliocene fauna of Italy, as exhibited along the valleys of the Po and of the Arno. But it must at the same time be freely admitted, that the materials upon which the determination of many of the species of the Red Crag Mammalia at present rests are so scanty and indecisive, that the identification, either way, whether as Miocene or Pliocene forms, must be regarded as little more than approximative.

There are other considerations which corroborate the Pliocene view of the Mammalian fauna of the Crag. The debateable species referred by Prof. Owen to a Miocene origin all belong to genera that are common to the Miocene and Pliocene periods—such as *Mastodon*, *Rhinoceros*, *Tapirus*, *Sus*, *Cervus*, and *Felis*. But of the more remarkable types which are limited to the Upper Miocene deposits, and which abound in them all over Europe, such as *Dinotherium*, *Chalicotherium*, *Aceratherium*, *Anchitherium*, *Amphicyon*, &c., not a single remain has ever been cited as having been found in the Crag-deposits. The question naturally arises, how does it happen,

* Quarterly Journal of the Geol. Soc. vol. xii. p. 237. fig. 20.

if the majority of the Red Crag Mammalia are Miocene, that there has been this selective admixture of species of long-termed "Miocene" genera in the Crag, and why the exclusion of the strictly characteristic genera?

Another view may be taken, that, as the Red Crag contains Fish and Crustacean remains which have been inferred to have been washed out of denuded Eocene deposits, so the Pliocene sea-bottom of the Red Crag may have had Miocene mammalian remains washed into it, thus causing an extraneous admixture among the Pliocene mammalian fossils. But it may be asked in reply, where are the Falunian deposits, in proximity with the Crag in England, from which such a washing-in could have taken place? And, if they were transported from a distance, they ought to show marks of abrasion from rolling, which, so far as my observation goes, are not seen in a great many of the Red Crag Mammalia to which a Miocene origin has been attributed. Many flattened pieces of bone, exhibiting a high vitreous polish, and bearing palpable marks of having been long rolled in the sea among shingle, have unquestionably been met with in the Crag; but it does not necessarily follow that they were all washed out of an older deposit. It is intelligible that the effect may have been produced by attrition caused by the waves of the Crag-sea upon bones of animals of the same geological period.

It now remains to consider how far the Cetacean fossils of the Crag are in accordance with the inferred Pliocene character of the Land Mammalia. Professor Owen has described "Cetotolites" of five species of *Balænidæ* from the Red Crag. He states (Brit. Foss. Mam. p. 527), that they "appear to have been dislodged from a subjacent Eocene deposit;" and the same opinion is repeated in the note appended to the "Conspectus" of British fossil species which I have already cited. They are there arranged under the head of Eocene, and excluded from the Miocene fossils. Cetacean remains have been met with in abundance in the Pliocene deposits of Italy, under circumstances which leave no doubt that they are of the same age as the land-quadrupeds found associated with them. I have already mentioned the case examined by myself, where the skeleton of *M.* (*Tetraloph.*) *Arvernensis,* covered with marine incrustations, was found in the "Panchina inferiore" of the lower Val d'Arno near Leghorn, associated with the entire skeleton of a whale referred by the Italian naturalists to *Physeter*, and with Dolphin-remains. A still more remarkable and conclusive instance is furnished by the rich and well-known deposit of Pliocene Mammalia investigated by Cortesi in the Subapennine deposits near Piacenza. Monte Pulgnasco is stated to attain an elevation of about 1700 feet above the level of the Adriatic *, and near it there are lower elevations, Monte Zago and Della Torazza. The upper beds in all three alike, to a great depth, consist of reddish calcareous sands full of marine shells; and below these there are beds of blue clay ("Marna cerulea"), also

* Cortesi, Saggio Geolog. 1819, p. 72.

loaded with similar shells, both being of the Subapennine Pliocene age. Cortesi discovered in the blue clay, at different points, nearly entire skeletons of extinct whales, referred by Cuvier to the Rorquals (*Balænoptera Cortesii* and *Balænoptera Cuvierii* *), and of Dolphins allied to *Phocæna Orca*, but differing in the form of the cranium (*Phocæna Cortesii* †, and other species unnamed). Near the summit of Monte Pulgnasco, in the overlying stratified sands, the greater part of a skeleton of the Val d'Arno Elephant, *E.* (*Loxod.*) *meridionalis*, was discovered; and upon Monte Zago the original skull, together with many other bones, of the individual Rhinoceros upon which Cuvier founded his *Rhinoc. leptorhinus* as distinct from *R. tichorhinus*. The Rhinoceros skeleton was found in the sandy strata, but resting immediately upon the blue clay, and with upwards of 200 feet of strata above it. I was enabled, by the kind permission of Dr. Emilio Cornalia, to examine the fine collection of these Monte Pulgnasco remains deposited in the Natural History Museum at Milan, including, among others, the palate specimen of the Elephant described by Cortesi ‡, which I found to be identical with *E.* (*Loxodon*) *meridionalis* of the Val d'Arno and Fluvio-marine Crag.

Here are two cases of the association of Pliocene Cetacea with terrestrial Mammals, under circumstances where extraneous admixture is inadmissible. Cetacean remains were long ago described by Cuvier from the Crag of Antwerp §. Lyell found in the same formation numerous specimens of bones said to be of *Balænoptera* and *Ziphius*, which bore no marks of rolling as if washed out of older beds; and he inferred that the animals to which they belonged once coexisted in the same sea with the associated Crag Mollusca ||. He considers the strata to be Older Pliocene, equivalents of the Red Crag and Coralline Crag.

Professor Owen, in his late memoir, enumerates some additions to the Cetacean remains from the Red Crag described in the 'British Fossil Mammalia.' Among these are portions of an upper jaw very closely resembling the *Dioplodon Becanii* of Gervais (*Ziphius* of Cuvier), and "water-worn teeth corresponding in size and form" with those of the *Hoplocetus crassidens*, an obscure and as yet imperfectly determined form, provisionally so named by Gervais ¶, from the Miocene Faluns of La Drôme. Another supposed species of the genus, named *Hoplocetus curvidens* by the same palæontologist, is founded upon specimens procured from the Pliocene sands of Montpellier. The Crag "Cetotolites" (*i. e.* the same species) have nowhere as yet been described as occurring in Eocene beds in England; and the whole bearing of the evidence would seem to in-

* Diction. Univers. d'Histoire Natur. tom. ii. p. 443.

† *Op. cit.* tom. iv. p. 634.

‡ Cortesi, *op. cit.* p. 68. t. 6. f. 1, 2.

§ Oss. Foss. tom. v. p. 352.

|| Quart. Journ. Geol. Soc. vol. viii. p. 281; and Manual of Geology, 5th edit. p. 174.

¶ Paléont. Franç. tom. i. p. 161. Gervais throws out a suggestion, that his *Hoplocetus* may have a connexion with the *Balænodon* of Professor Owen; but does not enter into a detailed comparison.

dicate, that at least a considerable part, if not the whole, of the "Red Crag" Cetacea are of the same age as the associated terrestrial Herbivora.

[Since the preceding pages were in type, I have had an opportunity of examining specimens in some of the principal collections in Essex, Suffolk, and Norfolk, which throw light upon some of the points discussed above. In the Town Hall of Colchester there is a fine specimen, comprising both maxillary bones of a young *Elephas* (*Eueleph.*) *antiquus*, and presenting the last milk-molar (right side) in place. The matrix is very ferruginous, and the bones and tooth are of a dark-chocolate colour, with a vitreous polish. It was dredged up from off the "West Rocks" on the Essex coast; and it resembles in its mineral condition the large Cervine horn reputed to be from a Crag-pit at Felixstow, and referred by Professor Owen to *Megaceros* (see above, p. 354).

In the rich and valuable collection of Red Crag fossils belonging to William Whincopp, Esq., of Woodridge, there are two upper and three lower molars of a species of *Hippotherium* from the Red Crag pits at Sutton. They bear a close resemblance to the Miocene *H. gracile*, Kaup, from Eppelsheim. The same collection contains several molars, upper and lower, of the genus *Rhinoceros*, one of which (an upper antepenultimate milk-molar) agrees, in most of the characters, with an original specimen of a corresponding tooth of *Rhinoceros Schleiermacheri* from Eppelsheim, with which it was compared. Mr. Whincopp also possesses an upper maxillary bone containing a series of the molar teeth of *Hyracotherium leporinum*; also detached molars apparently of the smaller species, *Hyrac. cuniculus*, both said to have been procured from the Red Crag at Felixstow. Besides these, Mr. Whincopp possesses, first, several perfect Cetacean teeth, resembling those referred to *Hoplocetus* by Gervais; 2ndly, two remarkable molar teeth of a form which has not hitherto been described as a British fossil; and, 3rdly, numerous remains of Red Crag *Delphinidæ*.

In the rich collection of Edward Acton, Esq., of Grundisburgh, there are specimens referable to both species of *Hyracotherium*, and reputed to be from Red Crag localities in Suffolk, besides molars of *Tapirus* and *Rhinoceros*. Mr. Acton also possesses a singularly perfect antepenultimate true molar from the lower jaw of *M.* (*Tetralophodon*) *Arvernensis*, showing the peculiar characters of the species strongly marked*.

In neither of these collections did I observe any specimen referable to *M.* (*Tetraloph.*) *longirostris* of Eppelsheim, nor to the peculiar mammalian genera of the Upper Miocene period, enumerated in a preceding paragraph as being usually associated with that species (p. 355). It is manifest that the Hyracotherian remains must have been derived from broken-up Eocene deposits; and the teeth of

* In Mr. Whincopp's collection there is a very beautiful specimen of an intact germ of an antepenultimate upper milk-molar, from the Red Crag, closely resembling the specimens figured by Croizet and Jobert.

Hippotherium indicate a similar inference of Miocene remains being mixed up with Pliocene forms in the reconstructed materials of the *Red Crag* deposit.—H. F., Oct. 20th, 1857.]

Conclusion.—On a review of the various facts and considerations discussed in the preceding pages, it seems clear that the Mammalian fauna of the Fluvio-marine Crag is of a Pliocene age. The undoubted association of *M.* (*Tetraloph.*) *Arvernensis* and of *E.* (*Loxodon*) *meridionalis* in this deposit admits of no other inference. The mixed contents of the Red Crag, including mammalian remains of different strata from the Eocene period upwards, are inferred to have been deposited in the reconstructed strata also within the Pliocene period; since *M.* (*Tetraloph.*) *Arvernensis*, which occurs so abundantly in the Red Crag, has not been met with anywhere on the Continent of Europe except in deposits of a Pliocene age. The Red Crag sea appears to have breached a previously established and populated Pliocene land, and to have buried the bones referable to various epochs in the same sea-bottom.

In the preceding remarks I have purposely excluded any reference to the *shell-evidence*, and confined the comparison strictly to the Mammalian Fauna. The Mollusca have unquestionably been wielded as a most powerful exponent of geological chronology, and of the successive physical changes which have taken place on the surface of the earth. But it will hardly be denied that the evidence presented by Mammalian remains, when obtained in sufficient variety and abundance, is of greater significance as a test of contemporaneous formation in geology, or the reverse:—1st, Because Mammalian genera and species are everywhere shown to be of more limited duration in time than the Mollusca; and, 2ndly, because from the vastly greater complexity of their relative functions, they are much more susceptible of being affected by the altered climatal conditions which are necessarily involved in every great physical change, and which conduce most to the extinction of species.

The conclusions to which the comparison has led are:—

1. That the Mastodon-remains which have been met with in the "Fluvio-marine Crag" and "Red Crag" belong to a Pliocene form, *Mastodon* (*Tetralophodon*) *Arvernensis.*

2. That the Mammalian Fauna of the Fluvio-marine Crag bears all the characters of a Pliocene age, and is identical with the Sub-apennine Pliocene Fauna of Italy.

3. That the Red and Fluvio-marine Crags, tested by their Mammalian Fauna, must be considered as beds of the same geological age.

[The sequel of this paper, Part 2, "On the species of ELEPHANT found fossil in England," with remarks upon the associated Mammalia, will be communicated at a future meeting of the Society.]

DESCRIPTIONS OF PLATES XI. & XII.

[The figures are all drawn on the scale of one-third of the natural size.]

PLATE XI.

Fig. 1. *Mastodon* (*Tetralophodon*) *longirostris*, Kaup, from Eppelsheim: plan-view of the penultimate true molar from the left side of the upper jaw. *a*, anterior talon; *t*, posterior talon; *b*, *c*, *d*, *e*, the four principal ridges which compose the crowns of the "intermediate molars" in the Tetralophodons. An irregular longitudinal cleft along the middle divides the crown into an inner and outer division.

Fig. 2. The same tooth, seen in profile.

[From a cast in the Society's Collection.]

Fig. 3. *Mastodon* (*Trilophodon*) *angustidens*, from the Dep. Gers, in the Sub-pyrenees: plan-view of the penultimate true molar from the left side of the upper jaw, showing the worn disks of the three principal ridges which compose the crowns of the "intermediate molars" in the Trilophodons. *a*, anterior talon; *t*, posterior talon; *b*, *c*, *d*, the three ridges. The longitudinal cleft is partially worn out.

Fig. 4. The same tooth, seen in profile.

[From a specimen in the Collection of M. Lartet, For. Mem. G. S., Seissan, Gers.]

PLATE XII.

[The letters to the figures refer to the same parts as in fig. 1, Pl. XI.]

Fig. 1. *Mastodon* (*Tetralophodon*) *Arvernensis*, from Ramsey, near Harwich: plan-view of the germ of the penultimate true molar from the right side of the upper jaw.

Fig. 2. The same tooth, seen in profile. A large flanking mammilla is seen to occupy the middle of each valley.

[This specimen is in the Collection of the Rev. J. R. Marsden, Great Oakley, Essex.]

Fig. 3. *Mastodon* (*Tetralophodon*) *Arvernensis*, from Suffolk: plan-view of the germ of the last true molar from the left side of the lower jaw. *b*, *c*, *d*, *e*, *f*, the five ridges composing the crown, the mammillæ of which are disposed alternately.

Fig. 4. The same tooth, seen in profile.

[Figs. 3 & 4 are drawn from a cast in the Society's Museum; the "bourrelet" being partly restored from a Crag molar of similar age, also in the Society's Collection.]

April 22, 1857.

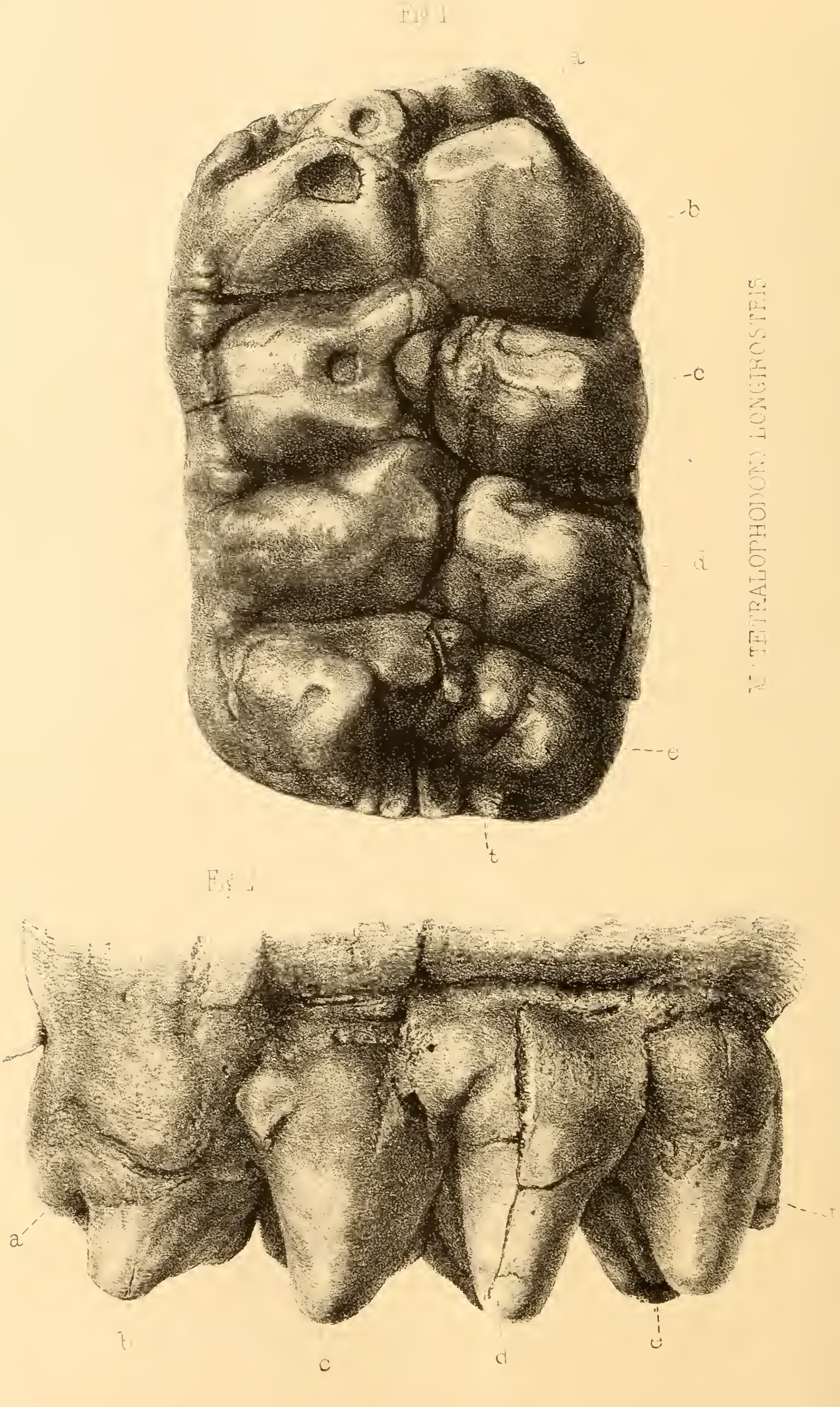
Thomas Alfred Yarrow, Esq., C.E., Gresham House, Old Broad Street, was elected a Fellow.

The following communications were read:—

1. *Description of a* New Fossil Crustacean (Tropifer lævis, *C. Gould*) *from the* Lias Bone-bed. By Charles Gould, Esq., B.A.

[Communicated by J. W. Salter, Esq., F.G.S.]

Crustacean remains from this Bone-bed, and indeed from the Lias itself, are so rare, that I feel no apology is necessary for introducing



M. TETRALOPHODON LONGIROSTRIS

M. (TRILOPHODON) ANGUSTIDENS.

Fig 3

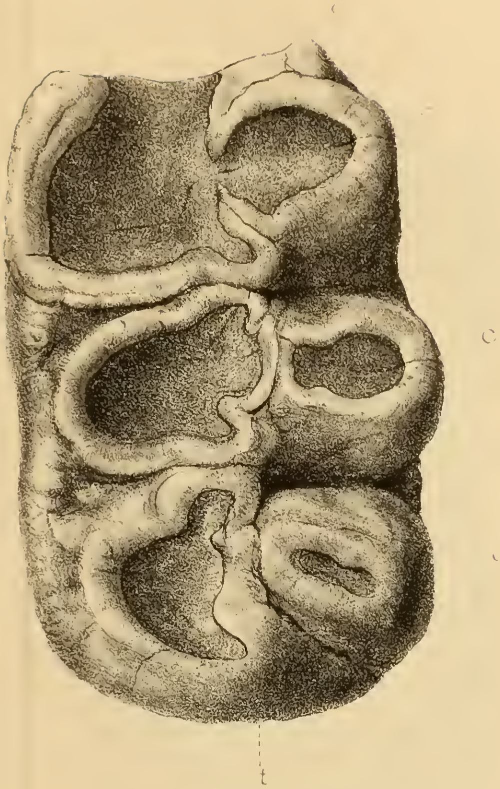
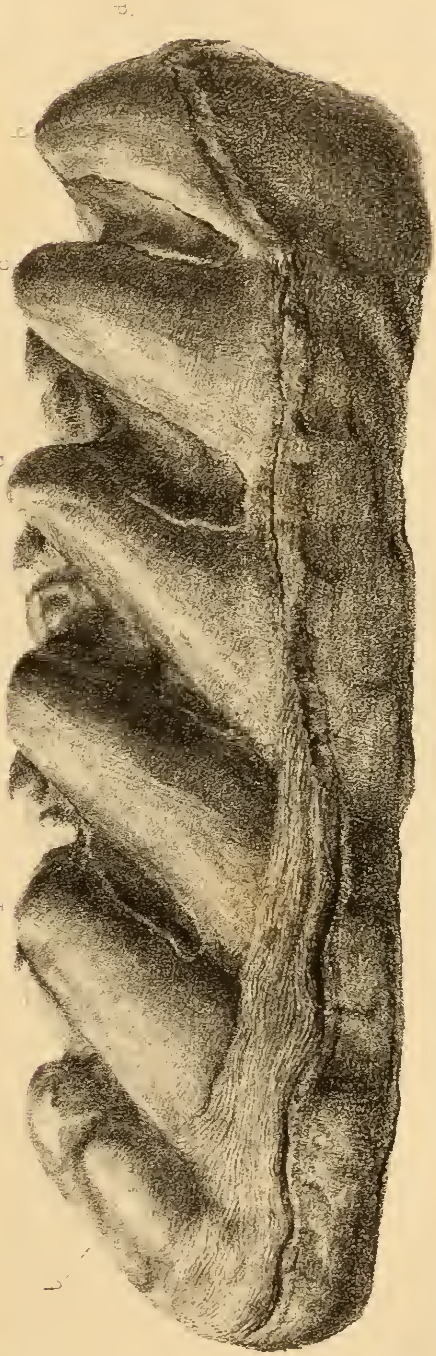


Fig 4

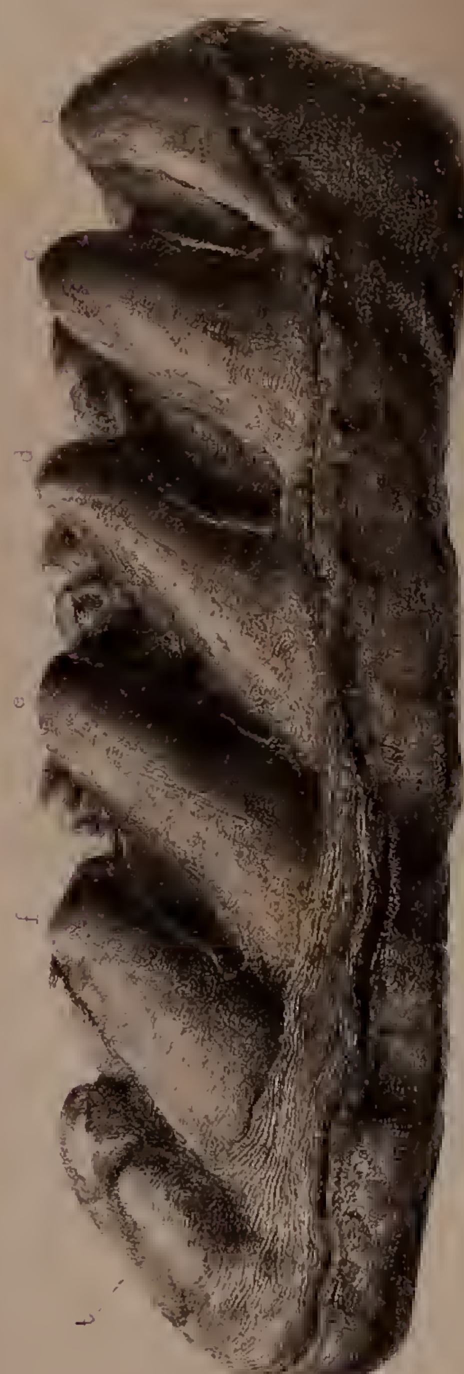
Fig 1



Fig

Fig. 1.

Fig 2



($\frac{1}{3}$ nat size)

MASTODON (TETRALOPHODON) ARVERNENSIS. From the Crag.

W West Imp

to the notice of the Society this small Decapod, which has been kindly lent to the Geological Survey by E. Higgins, Esq., of Birkenhead.

Tropifer lævis.

Carapace.—The carapace in this specimen (fig. 1, *b*, & fig. 3) is somewhat flattened and subrectangular, and has the posterior angles slightly produced ; the length is rather more than 3 lines, and the width, which is pretty constant throughout, $2\frac{3}{4}$ lines; it has three longitudinal ridges, one median and the others nearly parallel to it, but rather sinuous, and about equidistant between it and the lateral margin of the carapace, which is slightly thickened and crenulated, as are also the ridges.

Figs. 1, 2, & 3.—Tropifer lævis, *from the Lias Bone-bed at Aust Passage.*

Fig. 1.

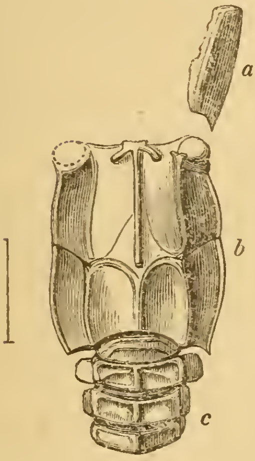


Fig. 2.

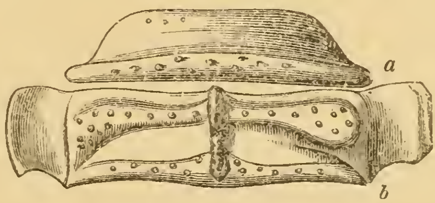


Fig. 3.

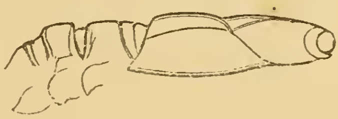


Fig. 1. Enlarged view of the specimen ; the natural length is shown by the line at the side. *a.* Fragment probably of one of the limbs ; *b.* Carapace ; *c.* Four abdominal segments.

Fig. 2. Two of the abdominal segments ; magnified :—*a*, the first ; *b*, the second segment.

Fig. 3. Side-view of the specimen, in outline, magnified.

The cervical furrow is distinct, cutting the median ridge at a little more than one-third from the posterior end ; its general direction is outwards and forwards to the edge of the carapace, which it meets at about two-fifths from its anterior end ; each half is divided into two portions by the lateral and longitudinal ridges : the outer portion is straight and the inner curved, with the convexity forwards, and from its most advanced point, an indistinct line runs forwards and inwards to the central ridge, giving rise to a deltoidal figure, in which the acute angle is anterior.

The front edge of the carapace is imperfect, but enough remains to show that it is truncate and emarginate beneath the lateral ridges, and rather outside of them, for the reception of the large eyes. One of the eyes is preserved, and appears to be spherical, and about half a line in diameter.

There is no appearance to indicate any prolongation of the front edge into a rostrum; nor are there any portions of the antennæ remaining. The posterior edge of the carapace is also emarginate (to receive the first segment of the abdomen); the ridges end abruptly upon it, without being produced into any spines or prolongations.

With the exception of an oblong tumidity on either side of the anterior end of the median ridge, there are no punctations, tuberculations, or sculpturings.

Abdominal segments.—Of the abdomen, which is rather depressed, four segments only are visible, measuring in all two lines in length; but the probability is, that the remainder are concealed in the matrix. In all those present, the articular facet is smooth, but the posterior portion of the first segment is elevated, and covered with small tuberculations, and in the succeeding segments it has a median ridge and lateral prominences corresponding to those upon the carapace (fig. 2).

In the second segment, the epimera are smooth and unornamented, and bent down at right angles to the tergum, which presents a peculiar ornamentation. In each half of the tergum there are two transverse, triangular elevations; the base of the larger and anterior one corresponding with the lateral ridge, the apex being connate with the central ridge; while in the posterior triangle, the base constitutes the hinder portion of the median ridge and the apex of the outer ridge; each of these elevations is tuberculated, and the spaces between them are smooth. The remaining segments present slight modifications, but are essentially similar (fig. 1, *c*).

The carapace is not overlapped by the first segment.

Limbs.—The few portions of limbs remaining are fragmentary. They are subtrigonal and several times longer than broad.

Locality.—The specimen under notice was found in a coprolitic mass from the Lias bone-bed at Aust Passage.

Affinities.—Although the carapace, in consequence of its flatness and the production of its posterior angles, presents a facies not very dissimilar from that of some Stomapods, such as certain species of the genus *Ericthys*, the general characters of the specimen are those of a Decapod; for it differs from the Stomapods in possessing a deep cervical furrow, extending right across the carapace, and dividing it into a cephalic and a scapular portion. This character does not occur, so far as I am aware, in any of the Stomapods; nor on comparing it with the recent species of this group, can I find any of these with the abdomen similarly ornamented.

Turning next to the four great divisions of the *Macrura*, I think that we may at once exclude that of the *Thalassinidæ*, containing such genera as *Callianidea* and *Thalassinus*, in which the slender and compressed abdomen, the slight integument, &c. are characters directly opposed to those of our specimen.

In three families of the division termed by M. Milne-Edwards "les Salicoques," viz. the *Crangonidæ*, the *Alpheidæ*, and the *Palæmonidæ*, there is no distinct cervical groove, while in the fourth, the

Peneidæ, although certain forms, as *Stenopus*, possess one, the other characters are quite dissimilar; moreover, the flattened scale above the antennæ, characteristic of all these families, appears to be wanting in our specimen, for I am inclined to consider the long subtrigonal fragment lying in front of the eye (and which possibly might be regarded as such) as a portion of one of the limbs, which has been displaced.

Neither among "les Crustacés Cuirassées" can it be referred to either of the genera *Galathea*, *Eryon*, or *Palinurus*: its general characters distinguish it from the first; the material difference in the width of the carapace, from the second; and the general form of the body, together with the absence of spines on the carapace, and more especially of the two prominent horns extending over the eyes and base of the antennæ, from the last.

The flatness of the carapace, and the remoteness of the eyes, are points of agreement with the genus *Scyllarus*; but on the other hand, in this specimen at least, there are no traces of the large expanded antennæ, which are so conspicuous in the latter. With regard to the last division, that of the *Astacidæ*, we need only select for comparison the genus *Nephrops*, which has a similar cervical furrow, a median ridge, running the whole length of the carapace, and two parallel lateral ones on the hinder half. In addition to this, the abdominal segments have very similar sculpturings. The position of the eye, however, in *Nephrops*, the convexity of the carapace, and its being overlapped by the first abdominal segment, are important differences.

In conclusion, I would remark that, although the characters are sufficiently well defined to render the genus and species identifiable by the description and figure given, and although in some respects there are indications of an affinity with *Nephrops* and *Scyllarus*, I do not think the evidence sufficient to justify me in assigning it to any existing genus of the *Macrura*.

I therefore propose to constitute it the type of a new genus, with the appellation of *Tropifer**, with the following, for the present necessarily incomplete, characters:—

Carapace flattened, keeled, slightly longer than broad, truncate in front, and having the posterior angles slightly produced; *eyes* large, remote; *abdomen* somewhat flattened, sculptured.

The specific name *lævis* is in allusion to the smoothness of the carapace.

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2. *Description of a* New Crustacean (Pygocephalus Cooperi, *Huxley*) *from the* Coal-Measures. By Prof. Huxley, F.R.S., F.G.S.

[Plate XIII.]

The following account of a very remarkable new Crustacean has been drawn up from the examination of three specimens, two of

* From τρόπις, *keel*, and φέρω, *I bear*.

which are the property of R. S. Cooper, Esq., of Bilston, while the third belongs to the Manchester Museum. The last-mentioned is the most perfect, and may therefore be conveniently described first, as No. 1 (Pl. XIII. fig. 1).

It was obtained from the coal-shales at Medlock Park Bridge, and consists of an ironstone-nodule split into two pieces, a larger and a smaller. The face of the latter exhibits a relief of the fossil, while the opposed surface of the larger piece presents the corresponding cast. Exclusive of the appendages, what we may call the body of the fossil (fig. 1 *a*) measures about $1\frac{1}{3}$ inch in length, and has a width of rather more than $\frac{5}{8}$ths of an inch at its widest part.

The one end of the body (fig. 1 *b*, *c*) is much broader than the other, and has the form of a semicircular disk, the base of the semicircle forming the widest part of the body, and being about half an inch distant from the summit of its curve.

The opposite end has the appearance of a quadrate disk (*a*), about $\frac{5}{16}$ inch long; and between this quadrate disk and the semicircular disk just described lies the central portion of the body (*b*) divided into a series of segments. Two pairs of appendages, one large (2′) and one small (1′), are attached to the extremity of the quadrate disk, while a number of slender limbs are connected with the sides of the segmented part of the body, the four pairs nearer the quadrate disk being directed towards that end of the body, while the others pass more directly outwards.

The semicircular disk (*c*) is traversed by a strong transverse depression about the middle of its length, which divides it into a wide proximal, and a narrower distal portion. The latter is convex in the direction of the long axis of the body, and presents a little tubercle on each side of the median line close to the transverse depression. The periphery of the distal portion has the form of a curved ridge, separated by a corresponding groove from the rest of the upper surface, and by another groove from the line of junction of the upper and lower surfaces (*e*). On clearing away the matrix as far as was practicable, I found the under surface of this part to be far more convex than the upper, and to present a transverse line apparently indicating the boundary of a segment. In consequence of its convexity inferiorly, this portion of the body has a thickness of as much as $\frac{3}{8}$ths of an inch.

The proximal portion of the semicircular disk appears to be somewhat crushed; it is divided by two well-marked longitudinal depressions, which converge from the ends of the transverse depression into a central lobe, narrower proximally than distally, and two lateral ones, whose wider extremities are turned in the opposite direction.

The proximal half of the quadrate disk (*a*) presents two convex lateral eminences, separated by a slight depression, which, like the distal half, is obscured by portions of the matrix. The larger lateral appendage (2′, 2″) attached to the distal half, is, on the right side, composed of a short, wide, basal articulation, with which a quadrate joint, produced into a spine at its outer and distal angle, and presenting a convex outer curve, is articulated. Apparently continuous with the under edge of this joint, is a flat, broad plate ($2''$), with an oval, distal contour, and presenting what appear to be traces of a fringe of setæ on one side. Regarding the quadrate joint and this plate as one part, they form a scoop-like scale, $\frac{1}{4}$ inch long by $\frac{1}{8}$ inch wide. Lying in the hollow of the scoop, and articulated either with its base or with the basal joint itself, is a fusiform mass ($2'$) divided by two constrictions into three joints, the middle one being shortest and subquadrate, while the inner and outer are conical. The outermost passes into a cylindrical multiarticulate filament, whose extremity is buried in the matrix. A longitudinal groove furrows the outermost articulation and is continued on to the filament, giving rise to an appearance of division—but I believe this to be accidental.

On the left side the appendage has a similar structure, but is less perfectly preserved.

The small appendages ($1'$) of the quadrate disk lie between the large ones. They consist of two proximal subcylindrical short joints, which do not equal more than half the length of the scale of the outer appendage; beyond these, traces are visible of another joint, and of a long, multiarticulate, terminal filament.

On the one side of the specimen, the matrix comes close up to the edge of the quadrate disk; but on the other, an elongated, narrow plate (*d*), with a somewhat excavated anterior margin, joins it at the base of the scale-like appendage. This plate is exposed for about $\frac{3}{32}$nds of an inch in width and $\frac{3}{8}$ths of an inch in length. Its outer margin is straight, and slopes outwards so that proximally it is $\frac{5}{16}$ths of an inch distant from the axis of the specimen, while distally (or at the base of the scale) it is only $\frac{1}{4}$ inch distant from the same imaginary line. A narrow triangular space, occupied by matrix, is left by the divergence of the plate from the central part of the body, and lodges three of its appendages on this side.

The central part of the body (*b*) measures about half an inch in length; it is narrowest towards the quadrate disk, widest at the opposite extremity, where it attains nearly $\frac{7}{16}$ths of an inch, and is divided into seven segments of nearly equal length, but gradually increasing breadth. Each segment appears to consist of a median plate, separated by an oblique furrow from two lateral plates; the latter are quadrate, with their margins concave outwardly and towards the quadrate disk; convex and somewhat raised, towards the semicircular disk. The median plate increases in width from the segment nearest the quadrate disk, which we may call the first, to the last. The lateral plates are nearly of the same size throughout, except the first pair, which appear to be larger than the others.

Attached to the outer boundaries of the lateral plates, seven appendages are observable on the left side, but only six on the right. In the more perfectly preserved appendages (fig. 1 *c*) there may be distinguished a short, proximal, convex, subcylindrical joint, followed by at least three other slender and delicate articulations; of these the proximal one is the longest, the terminal next in length, and the middle one shortest.

The terminal joint exhibits indications of further subdivision.

The fifth limb on the right side (the left side of the animal, as we shall see) presents a very important character, inasmuch as there lies parallel with and behind it a delicate, curved, many-jointed filament (fig. 1 *c*), which externally abuts against the terminal joint of the appendage, and internally lies parallel with the longer cylindrical joints, and in close contiguity with the basal division of the appendage. I believe, in fact, that this filament is nothing less than the outer division of the appendage, or its exopodite; and I am inclined to think that traces of a corresponding filament are visible in some of the other appendages.

No. 2 (fig. 3).—This specimen is the more perfect of the two belonging to Mr. Cooper. Like No. 3, it was obtained from the shale overlying the upper or thick coal-beds of Bilston, and is imbedded in a lighter-coloured ironstone than the foregoing, to which, in other respects, it bears a close resemblance. In fact, it presents precisely the same view of the fossil, and differs from the Manchester specimen chiefly in the absence of the semicircular disk, which is replaced by a deep pit in the relief, with which a corresponding elevation in the cast corresponds. The median part of the body and its appendages are similar to those above described, but the traces of the multiarticulate exopodite are but obscurely exhibited: the quadrate plate is of the same character, but its internal small pair of appendages are hardly traceable, though the external ones (fig. 3, 2″) are well preserved. The great feature of interest about the specimen is, that there lies on both sides of the quadrate disk a narrow plate (*d*), like that found on the one side only of the Manchester specimen. On the left side this plate does not extend further backwards than the proximal edge of the quadrate disk; but on the right side it is traceable as far as the fourth segment, and has, lying between it and the quadrate disk, the 1st, 2nd, 3rd, and 4th appendages of its side. On this side also the plate exhibits a slight transverse furrow ending in a small spine at the point marked (*d*). Distally, both narrow plates appear to be continuous with the quadrate disk.

No. 3 (fig. 2).—This specimen is much crushed and distorted, though the segments of the central division of the body, the appendages of one side, and the two scale-like bases of the large appendages of the quadrate plate are clearly visible. The great interest of this specimen proceeds, however, not from the existence of these parts, which are better shown in Nos. 1 and 2, but from the fact that in the place of the semicircular disk we see two broad plates convex from side to side, and a large portion of a third; all of them being obviously the lateral moieties of large segments similar to that whose boundary could be traced on the inferior convexity of the semicircular disk in No. 1 (fig. 1 *b*, *e*). On one side of the specimen (external to *b*, fig. 2) there lies a plate which probably corresponds with those marked *d* in the other figures.

A glance at the different specimens which have been described is sufficient to convince the investigator of their Crustacean nature;

but in endeavouring to make a further step, and to determine the precise order of *Crustacea* to which No. 1 was to be referred, I was for a long time obstructed by the difficulty of deciding which end was the head and which the tail, and whether the surface exposed to view in this and the other specimens was the ventral or the dorsal. At first I was inclined to regard the semicircular disk as a cephalic buckler; and, as the edges of this disk clearly overlap some of the limbs, I was led to think that the dorsal surface was visible, and that I had before me a most anomalous form, with a head something like that of an *Apus* or a Trilobite, the thorax of an Isopod, with the limbs of a Schizopod, and with the abdomen and caudal appendages altogether peculiar and anomalous. I was inclined to imagine, therefore, that this singular form combined the characters of several orders of *Crustacea*.

The high palæontological interest attaching to the discovery of such a form, however, led me to give additional weight to every argument adverse to the validity of this provisional interpretation; and, apart from these considerations, there were several circumstances which were great obstacles in the way of this view of the matter. I could not understand the nature of the elongated plate attached to one side of the quadrate disk in No. 1; the supposed caudal filaments were wholly without parallel in the Crustacean series; and I could not see in what part of the body the segments exhibited in No. 3 had their place. Furthermore, the form and apparent annulation of the under surface of the supposed cephalic buckler were quite incomprehensible.

All these doubts were greatly strengthened when Mr. Cooper kindly sent his specimen No. 2 for my inspection, which, exhibiting a flat plate attached to *both* sides of the quadrate disk, clearly proved that the one plate of the Manchester specimen was not a merely adventitious appearance, while the deep excavation at the end corresponding with the hemispherical disk seemed to show that, in this specimen also, the corresponding division of the body was very convex inferiorly. Now I know of no Crustacean possessing a cephalic buckler, in which that region is more convex ventrally than dorsally.

Perplexed by all these doubts, I next reversed my hypothesis; and, assuming the quadrate disk to be the head, the hemispherical disk to be the caudal extremity, and the exposed face to be ventral,—I sought to ascertain whether, by working out the necessary consequences of this supposition, I should not arrive at a result more in accordance with some of the known modifications of the Crustacean plan.

Upon this hypothesis, the small internal pair of appendages to the quadrate disk are antennules; the large external ones antennæ; the seven segments are the sterna of seven thoracic somites, increasing in width from before backwards; the narrow longitudinal plates are the edges of a short carapace; and the semicircular disk is the termination of a large abdomen bent upon itself, and having its caudal plates flattened out and crushed upon its anterior part. The two and a half segments in No. 3 are, on this hypothesis, nothing but so many of the abdominal somites viewed laterally.

If I had been acquainted with no part of these specimens but the quadrate disk and the segmented central portion of the body, I should have had no hesitation whatsoever in adopting this view of their nature; and even although the assumption that the semicircular disk is the crushed terminal portion of the abdomen may seem somewhat bold, yet it is the sole obstacle in the way of the only hypothesis which enables us to bring this singular form within the category of ordinary Crustaceans.

For if, adopting this theory of the sides and ends of the fossil, we compare it with the little *Mysis* or "Opossum-shrimp" of our own seas, we shall find some curious points of resemblance between the two.

In *Mysis* (fig. 5), as in *Pygocephalus*, the abdomen is very large as compared with the thorax, and the carapace is short and delicate. The antennules (1′) present two subcylindrical basal joints; the antennæ have two large basal joints giving attachment to a large scale (2″) externally and superiorly, while, internally, the fusiform base of the internal division of the antennæ is formed by three joints, with the last of which a very long multiarticulate filament is continuous.

There are seven pairs of *conspicuous* thoracic members in *Mysis*, the first pair of thoracic appendages (last cephalic of Milne-Edwards) being smaller than the others and applied against the mouth: so there are seven pairs of appendages in *Pygocephalus*, but the nature of the oral appendages in the fossil does not appear.

In *Mysis* again the thoracic limbs (fig. 4) are short and feeble, and consist of two parts, an endopodite and an exopodite, the latter being terminated by a many-jointed filament. They present the same peculiarities in *Pygocephalus*.

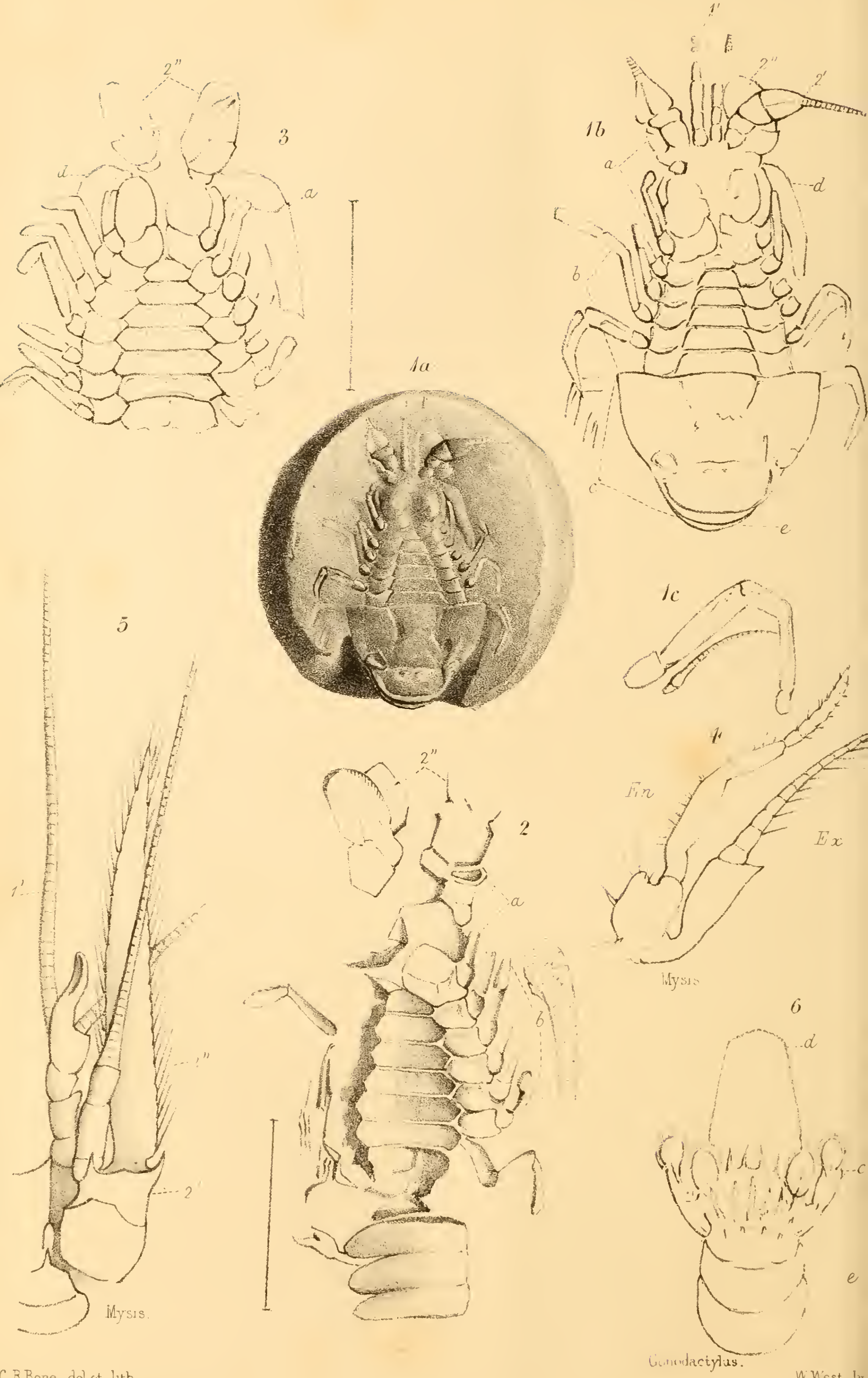
In *Mysis* the sterna of the thoracic somites are well developed and gradually increase in width from before backwards; so also, on this reading of the fossil, do those of *Pygocephalus*.

The abdomen of *Pygocephalus*, however, is much thicker and stronger in proportion than that of *Mysis*; and its telson and the appendages of the last somite, which together constitute the caudal fin, differ greatly in form from those of *Mysis*, being far wider. The outer edge of the caudal fin again in *Mysis* is nearly straight, while in *Pygocephalus* it is much curved.

In all these respects *Pygocephalus* more nearly approximates to the *Squillidæ*; and I have given a sketch of a *Gonodactylus* bent upon itself, and viewed from the ventral side (fig. 6), as I suppose the fossil to be, in order to show how closely the general proportions of the two genera approximate.

I cannot imagine that all these coincidences are accidental, and I conclude therefore that *Pygocephalus* is a Podophthalmous Crustacean in all probability more nearly allied to *Mysis* than to any other existing form.

At any rate we shall be quite safe in assigning to it a position



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Pygocephalus Cooperi

among either the lower *Decapoda* or the *Stomapoda** ; and supposing the interpretation which I have given of this difficult fossil to be well founded, it affords, so far as I am aware, the first certain evidence of the existence of *Podophthalmia* at so early a period as the Carboniferous epoch†.

DESCRIPTION OF PLATE XIII.

Fig. 1 *a*. *Pygocephalus Cooperi*, No. 1 : nat. size. The Manchester specimen.
Fig. 1 *b*. The same : magnified 1½ diameter.
Fig. 1 *c*. Thoracic appendage of the same . magnified.
Fig. 2. Mr. Cooper's specimen, No. 3 : magnified.
Fig. 3. Mr. Cooper's specimen, No. 2 : magnified.
Fig. 4. Thoracic appendage of *Mysis* : magnified.
Fig. 5. Antennule and antenna of *Mysis* : magnified.
Fig. 6. *Gonodactylus* bent upon itself, in outline ; the appendages being omitted : magnified.

a. Quadrate disk.
b. Central part of the body.
c. Semicircular disk.
d. Marginal portions of carapace.
e. Tergal surface of abdominal somites.
En. Endopodite. *Ex*. Exopodite.
1′. Antennules.
2′. Base and inner division of antenna.
2″. Outer division of antenna, or scale.

* I have elsewhere (Lectures on General Natural History, 'Med. Times and Gazette,' May 23rd, 1857) given my reasons for limiting the group of *Stomapoda* to *Squilla* and its immediate allies. The *Schizopoda*, including *Mysis*, are not essentially different from *Decapoda*.

† If the genus *Gitocrangon*, described by Richter (Beitrag zur Paläontologie des Thüringer Waldes, p. 43), really constitute, as its discoverer considers, a transition between the *Macrura* and *Brachyura*, it is not only an earlier, but a more highly organized Crustacean.

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3. *On the* Geology *of* Strath, Skye. By A. Geikie, Esq. *With Descriptions of some* Fossils *from* Skye ; by Dr. T. Wright.

(Communicated by Professor Ramsey, F.G.S.)

[This paper will be published in the next Number of the Journal.]

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American Journal of Sciences and Arts. 2nd Series. Vol. xxiii. No. 68. March 1857. *From Prof. Silliman, For. Mem. G.S.*

J. W. Bailey.—Microscopic Examination of Soundings from the Atlantic, 153.
Coal-fields of the East-Indian Archipelago, 157.
J. W. Mallet.—Rose-coloured Mica of Goshen, Mass., 180.
—— Analyses of Marble, Greensand, Iron-ores, &c., of Alabama, 181.
J. Hall.—Carboniferous limestones of the Mississippi Valley, 187.
—— Archimedes or Fenestella of the Carboniferous limestones, 203.
J. S. Newberry.—Formation of Cannel-coal, 212.
F. v. Kobell.—Notice of J. N. v. Fuchs, 225.
C. & A. Tissier, and Debray.—Alloys of Aluminium, 265.
Troost.—Lithia, 266.
W. P. Blake.—Telluret of Silver in California, 270.
J. Leidy.—Fossil Vertebrata from Carolina and Virginia, 271.
D. D. Owen.—Geological Survey of Kentucky, 272.
G. Jones.—Shower of ashes in Quito, 276.
J. Hall.—Palæotrochis of Emmons, 278.
H. Poole.—Visit to the Dead Sea, 290.
Notice of W. C. Redfield, 292.
Notice of Hugh Miller, 293.
Bibliography, 299.

——. ——. No. 69. May 1857.

J. D. Whitney.—The Huronian and Laurentian Systems of the Canada Geological Survey, 305.
J. B. Trask.—Earthquakes in California during 1856, 341.

American Journal of Sciences and Arts. No. 69 (*continued*).
G. P. Scrope.—Craters and Lavas, 346.
N. A. Pratt.—Two Sulphurets of Copper from the Canton (Ga.) Mine, 409.
F. A. Genth.—Contributions to Mineralogy, 415.
J. W. Mallet.—Separation of Lithia and Magnesia, 427.
Wöhler & Deville.—Boron, 433.
T. Coan.—Volcanic Action of Hawaii, 435.
I. A. Laphani.—Geological Survey of Wisconsin, 437.
T. S. Hunt.—Reaction of the alkaline silicates, 437.
Obituary Notice of J. W. Bailey, 447.
Obituary Notice of M. Tuomey, 448.

Assurance Magazine. Vol. vii. part 1. April 1857.

Athenæum Journal for April, May, and June 1857. *From C. W. Dilke, Esq., F.G.S.*
Notices of Scientific Meetings, &c.

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Biver and Nerenburger.—Les triangulations géodétiques, I. 88, 92, 99, II. 430.
Ad. de Vaux.—Gisement et formation de l'oligiste, de la limonite et de la pyrite, II. 69.
L. De Koninck.—La distribution de quelques fossiles carbonifères, II. 309.

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H. Schlagintweit.—Magnetic Survey of part of the Himalayas, 554.

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Index to vols. i. to xxiii. of the Journal, and to vols. xix. and xx. of the Asiatic Researches; with Appendix of classified lists of the Antiquarian, Geological, and Mineralogical papers in the Journal.

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Rammelsberg.—Ueber die chemische Zusammensetzung des Leucits und seiner Pseudomorphosen, 148.

Berlin. Monatsbericht der Kön. Preuss. Akad. der Wissen. 1856, Januar–October (*continued*).

Rammelsberg.—Ueber das Vanadinbleierz, 153.

Hagen.—Ueber die Fluth- und Boden-Verhältnisse des Preussischen Jade-Gebietes, 339.

Müller.—Ueber neue Crinoiden aus dem Eifeler Kalk, 353.

—— Ueber ein Echinoderm mit Schuppenförmigen Tafeln und Echinidstacheln im Eifeler Kalk, 356.

Ehrenberg.—Bericht über die Fortsetzung der Mikrogeologie, 362.

—— Ueber zwei neue südamerikanschen Gebirgsmassen aus mickroscopischen Organismen, 425.

G. Rose.—Ueber die Beschaffenheit und Lagerungsverhältnisse der Gesteine im Riesen- und Iser-gebirge, 444.

———. ————, for November and December 1856.

E. Mayer und v. Neimans.—Berichte über das Erdbeben vom $\frac{11}{22}$ Oct. 1856, 471.

Ewald.—Ueber die am nördlichen Harzrande vorkommenden Rudisten, 596.

Rammelsberg.—Ueber den Zoisit und seine Beziehung zum Epidot, so wie über die Zusammensetzung des letzteren, 605.

G. Rose.—Ueber Diamanten des königl. mineralogischen Museums, 652.

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Proceedings of the Society, 497.

Letters, 508.

A. Braun.—Ueber fossile Goniopteris-Arten, 545 (plate).

J. Roth.—Analysen dolomitischer Kalksteine, 565.

Von Huene.—Das Vorkommen von Galmei, Blende, Bleierz, Schwefelkies und Braunkohle bei Bergisch-Gladbach, 571 (plate).

—— Das Vorkommen von Hartmanganerz im Trachyt am Drachenfels am Rhein, 576.

Hermann Karsten.—Geognostische Bemerkungen über die Nordküste Neue-Granada's, insbesondere über die sogenannten Vulkane von Turbabo und Zamba, 579.

Meyn.—Eine neue Insel in Norddeutschland.

————. ————. Vol. v. 1. Heft. November, December 1852–Januar. 1853.

Proceedings of the Society, 1.

Letters, 14.

A. v. Humboldt.—Schichtung der Gebirgsarten am südlichen Abfall der Küstenkette von Venezuela gegen das grosse Becken der Ebenen (Llanos), 18 (plate).

Scacchi und Palmieri.—Ueber die vulkanische Gegend des Vultur und das dortige Erdbeben vom 14 August 1851, 21 (plate).

Von Franzius.—Fossile Ueberreste von Anthracotherium minimum und einer Antilopen-art aus Dalmatien, 75 (plate).

Von Strombeck.—Der obere Lias und braune Jura bei Braunschweig, 81.

Sonnenschein.—Ueber das Carolathin, 223.

E. E. Schmid.—Ueber die basaltischen Gesteine der Rhön, 227.

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Proceedings of the Society, 501.
Letters, 516.
J. Routh.—Bohrungen bei Wendisch-Wehningen, 522.
H. Karsten.—Die Pläner-Formation in Meklenburg, 527 (plate).
V. Schauroth.—Ein Beitrag zur Paläontologie des deutschen Zechsteingebirges, 539 (3 plates).
Scharenberg.—Bemerkungen über die geognostichen Verhältnisse der Südkuste von Andalusien, 578.
A. Erman.—Einige Beobachtungen über die Kreideformation an der Nordküste von Spanien, 596 (2 plates).
Bornemann.—Ueber Semionotus im oberen Keupersandstein, 612 (plate).

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G. Tate.—Farne Islands, 222.

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J. B. Phear.—Geology of part of Suffolk, 431.
O. Fisher.—Purbeck strata of Dorsetshire, 555.
W. Hopkins.—External Temperature of the Earth and the other Planets of the Solar System, 628.

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W. Bessemer.—Manufacture of Iron, 117.

———. No. 9. May 1857.

Hugh Miller's Testimony of the Rocks, noticed, 207.
Nott and Gliddon's Indigenous races of the Earth, noticed, 208.
G. D. Gibb.—Calcareous concretions from Buckinghamshire, England, 216.
D. D. Owen.—Kentucky Coal-fields, 217.
Friedel.—Zircon with basal planes, 218.
E. J. Chapman.—Calc-spar crystals from South Africa, 219.

Chemical Society, Quarterly Journal. Vol. x. No. 1. April 1857.

Civil Engineer and Architect's Journal. No. 277. April 1857.

Fowke.—On civil construction, 109.
Contour-levels, 127.

———. ———. ———. No. 278. May 1857.

J. Phillips and A. Ramsay.—Leading points in Geology, 135.
E. Burstall.—River Thames, 139.
W. Austin.—Artesian wells, 140.
J. Percy.—Steel, Platinum, Aluminium, &c. 151.

———. ———. ———. No. 279. June 1857.

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W. W. Smyth.—Report on the State of the Mining School, 17.
W. J. Henwood.—The Copper-turf of Merioneth, 41.

Critic. Nos. 381–390.

Notices of Scientific Meetings, &c.

Dublin Society (Royal), Journal. Nos. 4 and 5 (in one). January and April 1857.

McClintock and Haughton.—Geology and Fossils of Arctic Regions, 183 (6 plates and a map).

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De l'utilité d'un texte explicatif comme complément des cartes géologiques et agronomiques départementales ; du plan à suivre dans le confection de ce travail. Pp. 202, 261.

À quelles époques géologiques peut-on assigner le soulèvement et les mouvements successifs qui ont produit le relief du plateau central de la France ? P. 209.

À quelles causes faut-il attribuer la présence des blocs de gneiss et de porphyres empâtés dans certains gneiss et granites, et, en particulier, dans ceux de la Haute-Loire et de l'Ardèche ? Pp. 214, 358.

Des bassins houilliers de la Haute-Loire sous le rapport des accidents plutoniques qu'on y observe. Pp. 218, 361.

Existe-t-il des vestiges de terrains secondaires sur le plateau central de la France, et, dans le cas de l'affirmative, à quelle cause faut-il attribuer leur rareté ? P. 219.

Aymard.—Sur les collections de M. Pichot-Dumazel. P. 227.

Les gypses du bassin du Puy doivent-ils leur origine à un dépôt chimique, ou bien au métamorphisme des calcaires ? P. 244.

Déterminer l'époque géologique pendant laquelle ont éclaté les premiers volcans sur le plateau central de la France, celle où les volcans ont cessé de brûler, et quelles sont les caractères auxquels ont peut reconnaître leur âge relatif. P. 246.

Faut-il considérer les gemmes, tels que zircons, corindons, rubis, grenats, etc., qu'on rencontre dans les terrains volcaniques de Croustet et de Riou-Pezzouliou, près le Puy, comme les produits de la volcanisation, ou comme provenant de formations géologiques antérieures ? P. 255.

Croizet sur les collections paléontologiques et géologiques de M. Aymard. P. 258.

La paléontologie de la Haute-Loire offre-t-elle, pour certaines époques, des caractères qui la particularisent ? P. 261.

À quelle race humaine doit-on attribuer les ossements fossiles découverts dans les cendres volcaniques de Denise, près le Puy ? P. 277.

Les mammifères didelphes (marsupiaux) ont-ils apparu sur la terre avant les monodelphes ? À quelle époque géologique ont-ils disparu de l'Europe ? À quels genres de l'Amérique ou de la Nouvelle-Hollande pourrait-on comparer, sous le rapport des mœurs et des habitudes de vie, les genres fossiles, et, en particulier, le *peratherium* du terrain tertiaire des environs du Puy ? P. 315.

Aymard.—Sur des ossemens fossiles trouvés dans les brêches du volcan de Coupet. P. 319.

Assigner la place que doivent occuper, dans le classement général des mammifères, soit près des anoplothérides, soit avec les suillides, les divers genres de pachydermes fossiles qui ont reçu les noms de *chœropotamus, palæochœrus, entledon*, &c. P. 321.

Est-il établi, que le grand genre des mastodontes ait apparu sur la terre avant d'autres genres de proboscidiens ? P. 325.

À quel usage était appropriée la grande canine cultriforme qui arme la mâchoire supérieure des félides connus sous le nom de *machærodos* ou *smilodon*. P. 325.

Ces renouvellements successifs correspondent-ils à un nombre limité des plus grandes phases géologiques, ou bien se sont-ils produits plus fréquemment, à des intervalles de temps plus ou moins rapprochés, dans chacune de ces périodes ? P. 325.

Bertrand de Lom.—Sur un gisement de gemmes et d'ossements fossiles dans le canton de Langeac (Haute-Loire). P. 335.

De l'influence du sol chimique et du sol physique sur la végétation. P. 367.

Indiquer les moyens les plus simples et les plus à la portée des agriculteurs pour reconnaître la nature de leur sol, et celle des marnes, calcaires, argiles, sables, et, en général, de toutes substances qui peuvent être employées comme amendement. P. 376.

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Marcel de Serres.—Des caractères et de l'importance de la période quaternaire, 1257.

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M. Fournet.—Sur le terrain houiller découvert par des sondages au Creusot, 1266.

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Réunion extraordinaire à Paris, 1273.

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A. Favre.—Recherches sur les minéraux artificiels, 307.

A. Leymerie et G. Cotteau.—Catalogue des Echinides fossiles des Pyrénées, 349.

A. Leymerie.—Considérations géognostiques sur les Echinodermes des Pyrénées et des contrées annexes de cette chaîne de montagnes, 355.

Ville.—Notice minéralogique sur le cercle de Laghouat (Algérie), 366.

Gressly.—Découverte dans le *bone-bed* du canton de Bâle des restes d'un énorme Dinosaurien, 369.

J. Barrande.—Caractères distinctifs des Nautilides, Goniatides et Ammonides.—Etablissement du genre *Nothoceras* (pl. xii.), 372.

Ward.—Note sur la montagne nommée *Gebel Nakous,* ou montagne de la Cloche (Arabie-Pétrée), 389.

Th. Ebray.—Comparaison des oolithes inférieures du bassin anglo-parisien avec celles du bassin méditerranéen, 395.

Ville.—Notice minéralogique sur la province d'Alger, 399.

———. ———. ———. Vol. xiii. feuill. 26–30. 1856.

Ville.—Notice minéralogique sur la province d'Alger (fin), 401.

A. Meugy.—Sur le gisement, l'âge et le mode de formation des terrains à meulières du bassin de Paris, 417.

V. Raulin.—Note sur la constitution géologique de l'île de Crète, 439.

J. Barrande.—Parallèle entre les depôts siluriens de la Bohême et de la Scandinavie, 461.

A. Boué.—Parallèle des tremblements de terre, des aurores boréales et du magnétisme terrestre, mis en rapport avec le relief et la géologie du globe terrestre, etc., 466.

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H. Coquand.—Mémoire sur le terrain permien et le représentant du grès vosgien dans le département de Saône-et-Loire et dans les montagnes de la Serre (Jura), (pl. i.), 13.

Ch. Lory.—Note sur les terrains crétacés de la vallée de Dieu-le-Fît (Drôme), 47.

H. Coquand.—Note sur la formation crétacée du département de la Charente, 55.

France, Bulletin de la Société Géologique de, vol. xiv. (*continued*).
Scarabelli.—Sur un sondage artésien exécuté à Conselice (province de Ferrare), 102.
J.-J. Bianconi.—Note sur l'origine métamorphique des argiles écailleuses du terrain serpentineux des environs de Bologne (Italie), 105.
P. de Berville.—Note sur une nouvelle espèce de crustacé fossile trouvée dans le calcaire grossier inférieur (pl. ii.), 108.

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C. Giebel.—Die Versteinerungen im Muschelkalk von Lieskau bei Halle, 53 (7 plates).

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Bronn.—Ueber das Meteoreisen von Atacama, 10.
Schiel.—Reisebericht [Rocky-mountains, &c.], 11.
Blum.—Ueber die hohlen Geschiebe von Lauretta im Leithagebirge, 15.

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T. Oldham.—Coal and Iron of Talcheer, 1.
W. T. and H. F. Blanford, and W. Theobald, jun.—The Talcheer Coal-field, 33 (2 plates & map).
Dalton and Hannay.—Gold-yielding deposits of Upper Assam, 90.
T. Oldham.—Gold and Gold-dust from Shuè-gween, 94.

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Notices of Scientific Meetings, &c.
Miller's Testimony of the Rocks, noticed, 365 & 392.

Literary Gazette for April, May, and June, 1857 (*continued*).

Lyell's Supplement to 5th Edit. of Manual of Geology, noticed, 368.

Geological Survey of India, noticed, 420.

London, Edinburgh, and Dublin Philosophical Magazine. 4th Series. Vol. xiii. No. 86. April 1857. *From R. Taylor, Esq., F.G.S.*

T. S. Hunt.—Chemical composition of the waters of the St. Lawrence and Ottowa Rivers, 239.

W. J. M. Rankine.—Stability of loose earth, 292.

H. S. Ongley.—Earthquake in Crete, 293.

D. T. Ansted.—Mineral veins (Cuba, Baltimore, Tennessee), 293.

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A. B. Northcote.—Allophane, 338.

W. H. Miller.—Application of Elementary Geometry to Crystallography, 345.

D. Forbes.—Chemical composition of the Silurian and Cambrian limestones, 365.

H. J. Brooke.—The Geometrical Isomorphism of Crystals, 373.

R. Owen.—Dichobune ovina of the Isle of Wight, 385.

H. Falconer.—Plagiaulax of the Isle of Purbeck, 385.

Sir P. Egerton.—Fish-remains from Ludlow, 386.

Sir R. Murchison.—On the beds with fish-remains near Ludlow, 387.

W. Bollaert.—Mastodon bones in Chile, 388.

A. Damour.—Eudialite and Eukolite, 391.

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H. Falconer.—On the species of Mastodon and Elephant occurring in Great Britain, 462.

C. Gould.—On a Crustacean (*Tropifer lævis*) from the Lias Bone-bed, 465.

T. H. Huxley.—On a Crustacean (*Pygocephalus Cooperi*) from the Coal-measures, 465.

A. Geikie.—On the Geology of Strath, Isle of Skye, 466.

J. J. Monteiro.—On a new locality for Atacamite, 470.

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V. Kiprijanoff.—Zweiter Beitrag zu Hybodus Eichwaldi, 392 (plate).

Lindenmayer.—Eubœa, 401.

J. T. Weisse.—Die Schwarz-Erde (Tscherno-Sjom), 452.

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Buhse.—Eine Reise durch Transkaukasien und Persien, 86, 267.

E. Eichwald.—Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands, 433.

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E. Eichwald.—Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands, 88.

N. Nordenskiold.—Demidovite, nouvelle espèce minérale de Nijne Taguil dans l'Oural, 128.

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Gressly.—Coupe géologique du tunnel projeté pour le chemin de fer de la Chaux-de-Fonds, 2.

Ed. Desor, Rion, Th. de Meuron, Vonga, et F. Borel.—Tremblements du terre, 3, 43.

Ed. Desor.—Goniopygus, 11.

Gressly.—Ossements fossiles d'un Dinosaur, qu'il a découverts récemment dans le canton de Bâle, 13.

G. De Tribolet.—Carte géologique des Environs de Sainte Croix, 14.

Ed. Desor.—Le Clivage des roches, 54.

A. Jaccard.—Sur la Flore Fossile du terrain d'eau douce supérieur du Locle, 57.

G. De Tribolet.—Catalogue des Fossiles du Néocomien Moyen de Neuchâtel, 69.

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Glépin.—Sur le nouveau mode d'extraction et de triage de la houille appliqué aux mines du Grand-Hornu (Belgique), 149 (plates).

Rossi.—De la fabrication du fer par l'emploi des Lignites, 299.

Delesse.—Sur la pierre ollaire, 333.

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E. Morris.—Ohio River, 73.
C. Ellet.—Ohio River, 78.
Bessemer.—Iron-manufacture, 133.

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E. Morris.—Improvement of the Ohio River, 145.
Aluminium, 210.

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H. D. Rogers.—Geology and Physical Geography of North America, 319.

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A. Beardsley.—Diatomaceous deposit in Leven Water, near Coniston, 146.

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T. S. Hunt.—The Serpentines of Canada and their associated rocks, 423.
P. Yorke.—Silica, 440.

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Holmberg, H. J. — Hydrographische und orographische-geognostische Beobachtungen im nördlichen Finnland, als Ergebnisse der Golduntersuchungen in den Jahren 1847, 1848, und 1850, 1 (map).
Jeremejew, P.—Geognostische Beobachtungen an den Ufern des Wolchow, 63.
Romanowsky, G.—Geognostische Uebersicht des südlichen Theils des Gouvernements Rjasan, 85 (map).
Meglitzky, N.—Geognostische Skizzen von Ost Sibirien. I. Der Baikal und seine Umgebungen, 109 (map).
Gadolin, A.—Beobachtungen über einige Mineralien aus Pitkäranta in Finnland, 173 (plate).
Barbeaut-de-Marny, N.—Mineralogische Novellen vom Ural, 197.
Mendellejew, D.—Pyroxen aus Ruskiala in Finnland, 207.

St. Petersburg. Verhandlungen der Russisch-Kaiserlichen mineralogischen Gesellschaft zu St. Petersburg (*continued*).
Kutorga, S.—Notiz über einige Verhältnisse der Felsarten Finnlands, 211.
—— Fucus in den silurischen Kalksteinen des Gouvernements von St. Petersburg, 217.
Fahrenkohl, A.—Flüchtiger Blick auf die Bergkalk- und Jura-Bildung in der Umgebung Moskwas, 219 (2 plates).
Lawrow, N.—Zwei neue Asaphus-Arten aus den silurischen Kalksteinen des Gouvernements St. Petersburg, 237 (2 plates).
Kutorga, S.—Berichte über die Fortschritte mineralogischer Wissenschaften in Russland in den Jahren 1854 und 1855, 241.

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C. Binks.—Manufacture of iron and steel, 407.

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R. K. Warthausen.—Merkwürdiger Blitzschlag im Jahre 1854, 387.

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Von Fehling.—Chemische Untersuchung einiger Quellen des neuen Stuttgarten Mineralbades bei Berg, 113.
Fraas.—Geognostisches Profil einiger Bohrlöcher im Stuttgart-Constatter Thale, 131.
A. Oppel.—Die Juraformation Englands, Frankreichs und des südwestlichen Deutschlands, 141.

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W. C. Trevelyan.—Address (Notice of some Permian fossils), 333.

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T. Sopwith.—Address (Coal-seams, Coal-structure, &c.), 5, 24, 34.

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Fried. Rolle.—Geologische Untersuchungen in dem Theile Steiermarks zwischen Gratz, Obdach, Hohenmauthen und Marburg, 219.
Ferd. von Lidl.—Beiträge zur geognostischen Kenntniss der Steinkohlen-Formation im Pilsener Kreise in Böhmen, 249 (plate).
Karl Koristka.—Bericht über einige in den Sudeten, in den Bieskiden und im westlichen Mähren ausgeführte Höhenmessungen, 279.
K. Reissacher.—Der neue Quellenstollen in Wildbad-Gastein im Jahre 1856, 307.
Ferd. Hochstetter.—Allgemeiner Bericht über die geologische Aufnahme der I. Section der k. k. geologischen Reichsanstalt in Böhmen im Sommer 1855, 316.
M. V. Lipold.—Erläuterung geologischer Durchschnitte aus dem östlichen Kärnten, 332 (plate).
—— Höhenbestimmungen im südöstlichen Karnten, 346.

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Moriz Hörnes.—Sammlungen von Tertiär-Petrefacten des Wiener Beckens, aus den Doubletten der k. k. geologischen Reichsanstalt, zur Vertheilung und zum Tausche zusammengestellt, 353.

J. Barrande.—Bemerkungen über einige neue Fossilien aus der Umgebung von Rokitzan im silurischen Becken von Mittel-Böhmen, 355.

K. R. von Hauer.—Arbeiten in dem chemischen Laboratorium der k. k. geologischen Reichsanstalt, 360.

Sitzungen der k. k. geologischen Reichsanstalt, 362.

Verzeichniss der mit Ende Juni 1856 loco Wien, Prag, Triest und Pesth bestandenen Bergwerks-Producten-Verschleisspreise, 402.

————. ————. ————. No. 3. July–September.

Dionys Stur.—Die geologischen Verhältnisse der Thäler der Drau, Isel, Möll und Gail in der Umgebung von Lienz, ferner der Carnia im venetianischen Gebiete, 405 (3 plates).

D. Stur und F. Keil.—Barometrische Höhenmessungen aus dem Gebiete der obersten Drau in der Umgebung von Lienz und aus dem oberen Gebiete der Piave und des Tagliamento, 459.

Ferd. Hochstetter.—Ueber die Dachschieferlager des Ziegenruckberges bei Rabenstein im Egerer Kreise in Böhmen, 466.

Johann Jokély.—Zur Kenntniss der geologischen Beschaffenheit des Egerer Kreises in Böhmen, 479.

F. Rolle.—Die tertiären und diluvialen Ablagerungen in der Gegend zwischen Gratz, Köflach, Schwanberg und Ehrenhausen in Steiermark, 535.

K. R. von Hauer.—Arbeiten in dem chemischen Laboratorium der k. k. geologischen Reichsanstalt, 603.

Verzeichniss der mit Ende September 1856 loco Wien, Prag, Triest und Pesth bestandenen Bergwerks-Producten-Verschleisspreise, 626.

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G. Sandberger.—Geognostiche Skizze des Amtes Reichelsheim, 114 (map).

C. B. Greiss.—Ueber den Magnetismus der Eisenerze, 127.

Fresenius.—Die Mineralquelle zu Weilbach, 145.

G. Kerner.—Chemische Analyse der heissen Mineralquelle im Badhause zum Spiegel in Wiesbaden, 179.

F. Carl.—Untersuchung der warmen Quelle des Gemeindebades in Wiesbaden, 192.

A. Eglinger.—Analyse eines Schalsteins von Villmar, 205.

Proceedings of the Society, 216.

II. GEOLOGICAL CONTENTS OF PERIODICALS PURCHASED FOR THE LIBRARY.

Annals and Magazine of Natural History. 2nd Series. Vol. xix. No. 112. April 1857.

W. K. Parker and T. R. Jones.—Foraminifera, 273 (2 plates).
R. Howse.—Permian fossils, 304.
W. King.—Rhynchonella Geinitziana, 349.

———. ———. ———. No. 113. May 1857.

S. P. Woodward.—Land and freshwater Shells of Khasmir and Tibet, 408.
R. Owen.—Dichobune ovina, 426.
H. Falconer.—Plagiaulax, 426.
Sir P. G. Egerton.—Fish-remains from Ludlow, 427.

———. ———. ———. No. 114. June 1857.

R. Howse.—On the Permian System of the Counties of Durham and Northumberland, 463.
S. P. Woodward.—On the Mantle and Oral Apparatus of *Terebratula caput-serpentis*, 482.

Edinburgh New Philosophical Journal. New Series. No. 10. April 1857.

L. Blodgett.—Distribution of heat in the North American climate, 205.
W. S. Symonds.—Triassic rocks of the vale of Worcester and at the Malvern Tunnel, 257.
P. B. Brodie.—Notice of corals in the lias of Gloucestershire, Worcestershire, Warwickshire, and Scotland, 260.
W. Crowder.—Iron-manufacture in the Cleveland district, 264.
H. C. Sorby.—Physical Geography of the Tertiary Estuary of the Isle of Wight, 275 (plate).
D. Page's Text-book of Geology, noticed, 330.
W. H. Emory.—United States and Mexican Boundary Survey, 331.
C. F. Winslow.—Volcanic phenomena, 359.
J. E. Gavit.—Garfish, 359.
A. Winchell.—Geology of Middle and Southern Alabama, 359.
J. W. Dawson and W. B. Rogers.—Parallelism of rock-formations in Nova Scotia and other parts of America, 359.
J. Wyman and L. Agassiz.—Carboniferous reptiles, 360.
J. W. Foster.—Fossil Elephant of North America, 361.
James Hall.—Geology of the Upper Mississippi Valley, 362.
J. D. Dana.—Geological history of North America, 362.
J. D. Whitney.—Inclined stratification in Warren County, New York, 363.
J. P. Lesley.—The Broadtop Coal-region in central Pennsylvania, 363.
J. S. Newberry.—Fossil fishes and Coal-beds of Linton, Ohio, 364.
T. S. Hunt.—Some Euphotides and other felspathic rocks, 366.
—— The Serpentines of the Green Mountains, 367.
A. H. Worthen and L. Agassiz.—Fish-remains from the Carboniferous Limestone and Coal-measures of Illinois, 367.

Edinburgh New Philosophical Journal, No. 10 (*continued*).

J. H. and W. C. Redfield.—Relation of the Post-permian fishes of Connecticut and other Atlantic States to the Triassic and Jurassic Periods, 369.

E. Emmons.—Permian and Triassic Systems of North Carolina, 370.

W. P. Blake.—Geography of the Western portion of the United States, 370.

W. S. Symonds.—Organic remains at Kidderminster, 380.

J. S. Newberry.—Geology of northern California and Oregon, 380.

Bailey.—Volcanic cinders at the bottom of the Atlantic, 381.

Maury and Rodgers.—Deep-sea soundings in the Arctic Ocean, 382.

The Gulf-stream and its deposits, 383.

Hewitt.—Annual production of iron, 384.

Waugh.—Height of the Himalayas, 384.

III. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

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M'Clintock, Capt., Reminiscences of Arctic Ice Travel in search of Sir J. Franklin by; with Geological notes and illustrations by the Rev. S. Haughton. *From the Rev. Prof. Haughton, F.G.S.*

Memoirs of the Geological Survey of India. Vol. i. Part 1. *From the Geological Survey of India.*

Meteorological Register kept at the Hon. East India Company's Observatory at Madras for 1822–43. *From the Hon. E. I. Company.*

Observations made at the Magnetical and Meteorological Observatory at Toronto in Canada. Vol. i. *From the British Government.*

Oppel, A. Die Jura-Formation Englands, Frankreichs und des Südwestlichen Deutschlands. Drittes Heft.

Oppel, A., & E. Suess. Ueber die muthmasslichen Aequivalente der Kössener Schichten in Schwaben.

Parker, W. K., & T. R. Jones. Description of some Foraminifera from the Coast of Norway.

Phillips, J. On the Geology of the Malvern Hills. *From the Rev. W. Dyson.*

Pictet, F. J. Traité de Paléontologie, ou Histoire Naturelle des Animaux Fossiles. 2de édit. Vol. iv. with Atlas of plates.

Pusey, Ph. On the Source and Supply of Cubic Saltpetre. 2nd Edition. *From W. Bollaert, Esq.*

Quetelet, A. Rapport adressé à M. le Ministre de l'Intérieur, sur l'État et les Travaux d'Observatoire Royal. 1856.

Report and Memorial on Syrian Exploration. *From W. Ferguson, Esq., F.G.S.*

Ruskin, J. Modern Painters, vol. iv.; containing Part 5 of Mountain Beauty.

Schmidt, J. F. J. Die Eruption des Vesuv im Mai 1855; mit Atlas.

————. Neue Höhen-Bestimmungen am Vesuv.

Shumard, B. F. Description of New Fossil Crinoidea from the Palæozoic Rocks of the United States.

Smith, G. Vistas en la Provincia de Tarapacá, y del Puerto de Arica. *From W. Bollaert, Esq.*

Sorby, H. C. On the Physical Geography of the Tertiary Estuary of the Isle of Wight.

Swallow, G. C. The first and second Annual Reports of the Geological Survey of Missouri. *From James Colquhoun, Esq., F.G.S.*

Tate, G. The Farne Islands.

Trimmer, J. On the Agricultural Relations of the Western portion of the Hampshire Tertiary District.

Tuomey, M., & F. S. Holmes. Fossils of South Carolina, Nos. 3 to 7; and Circular.

Zepharovich, V. R. von. Die Halbinsel Tihany im Platten-See und die nächste Umgebung von Füred.

————. Die Silur-Formation in der Gegend von Klattau, Prestitz und Rozmital in Böhmen.

Zigno, A. de. Sulla Flora Fossile dell' Oolite.

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. XIII.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Equivalents of the "Kössen Strata" *in* Suabia. By Dr. A. Oppel and M. E. Suess.

[Proceedings Imp. Acad. Vienna, July 1856.]

A well-developed group of secondary rocks has been observed in the Eastern Alps, subsequently to the discovery of the organic remains of the St. Cassian beds. The series has a palæontological character of its own, differing in that respect from any other sedimentary formation hitherto known.

The group in question may be divided into two sub-groups, distinctly separated from each other by the nature of their organic remains, although conformable in stratification (as far as at present observed) and equally affected by the powerful upheavings of subsequent periods. Each of these sub-groups has, in certain localities, a thickness of several thousand feet; both of them are of purely marine origin; and limestones greatly predominate in both.

The inferior deposit, to which belong the beds of St. Cassian and Hall in Tyrol, the Hallstadt beds in Upper Austria, the deposits of Esino in the Lombardian Alps, and of Raibl in Carinthia, are now known to contain about 800 species of organic remains, not one of which is found anywhere beyond the East Alpine territory.

The superior deposit, comprising the Kössen beds in Tyrol, those of Starhemberg and of Kitzberg near Pepnitz in Lower Austria, of Bellagio on the Lake of Como, of Seesaplana in the Vorarlberg, and of the Stockhorn, together with the whole calcareous deposit known as "Dachstein Limestone," is admitted by the Austrian geologists to be more nearly connected with the Lower Lias than is the lower sub-group of Hallstadt and St. Cassian. The Swiss naturalists, however, think that this Kössen group should be united with the lower sub-group under the common denomination of St. Cassian Formation; the separation lying, as they suppose, not below, but above the Kössen Beds. This question having no influence on the opinions regarding the stratigraphical order of the deposits, we may now set it aside; and, in order to prevent any misunderstanding, we intend to use the term "Cassian Strata" for the lower sub-group exclusively.

No strata exactly concordant in palæontological characters with those in question having been found among the marine deposits of Western Europe, German and other naturalists have acquiesced in the opinion that the chronological equivalents of these deposits were to be sought for elsewhere, in the Keuper strata deposited in shallower water. This hypothesis still wants more proofs, on account of the totally discrepant physical circumstances under which the Keuper was formed, and on account of recent deposits covering all the area between the genuine Keuper and the Alpine sedimentary rocks.

MM. Escher v. der Linth*, of Zurich, and P. Merian†, of Basle, both of whom possess the knowledge and energy requisite for the solution of this question, have lately visited the Vorarlberg, where the genuine Cassian and Kössen beds begin to assume a more littoral character, particularly conspicuous in the Cassian beds. These eminent geologists succeeded further in finding out some relations between the Keuper and the Cassian beds, which led them to seek in the Upper Keuper for the equivalent of the Kössen beds.

We now intend to give a description of certain strata occurring in Suabia intercalated between the true Keuper and the lowest Lias with *Ammonites planorbis*. These strata seem to us to offer some remarkable analogies with the Kössen strata.

In West Germany, France, and England the Keuper appears generally in the form of a great marl-deposit with local occurrences of sandstone, gypsum, and dolomite beds of varying thickness. The subdivision of the Keuper formation, as now in use, depends on local petrographical differences. The Wirtemberg Keuper is considered to be normally developed when its component beds (of a total thickness of 700 feet) succeed each other in the following order:—

6. Red Keuper marls; overlaid by the hard yellow sandstones of the Bone-bed.
5. Sandstone (Stuben-sandstein).
4. Marls with bands of sandstone.
3. Argillaceous sandstones (fit for building-purposes).
2. Variegated marls.
1. Gypsum.
(Dolomite; generally ranked with the argillaceous coal series.)

Such subdivisions offer exceptions even at short distances, one or other of the beds disappearing; they may serve for practical purposes or for local characters, but they are not adapted for tracing the parallelism of strata for great distances. Many of the stratigraphical characters undergo alteration on the opposite side of the Rhine; variegated marls (Marnes irisées) here become prevalent, and the subordinate beds of heterogeneous rocks‡ occurring in it succeed in an order quite different from that of the Wirtemberg beds. This is still more conspicuous in the English Keuper. The coast of Axmouth (Dorsetshire) presents high cliffs of denuded New Red (Keuper) exclusively composed of variegated marls, not admitting lines of separation analogous to those traceable in foreign Keuper deposits. It has hitherto been impossible to make out in the Keuper petrographical horizons which may be recognized in distant countries; nor have observers succeeded in establishing zones with determinate and constant palæontological characters, indicative of coeval strata wherever they may be met with.

* "Geologische Bemerkungen über Vorarlberg" in the Helvetian Transactions for 1853; and Quart. Journ. Geol. Soc. vol. xi. part 2. Miscell. p. 16, &c.

† In the "Verhandlungen der Basler naturforsch. Gesellschaft," 2 series, Nos. 1 & 2, &c.; and Quart. Journ. Geol. Soc. vol. xi. p. 451.

‡ Dufrénoy & E. de Beaumont.—Explicat. de la Carte Géol. de la France, t. ii. pp. 57, 58.

The Keuper of West Germany, the Marnes irisées of France, and the New Red of England are sandy and muddy deposits not containing organic remains sufficient (as are those of the Jurassic or Cretaceous marine deposits) to establish the coevality of their respective subdivisions. The study of the vegetable remains in the Keuper Sandstone does not seem to have led to any positive result on this question; nor do the few, and generally ill-preserved, remains of Keuper shells, as hitherto described*, materially contribute to its solution. The large Labyrinthodont saurians, whatever may be their palæontological interest, are but seldom of essential use in comparative stratigraphy.

Recently the Suabian geologists have paid considerable attention to certain fossiliferous sandstone-strata intercalated between the Lias and the Keuper, and immediately connected with the Bone-bed, well-known for the great number of vertebrate remains contained in it. We shall now describe these sandstone-strata in some detail.

The stratigraphical order of these beds in the environs of Esslingen is as follows:—

Lias ...	Clays with beds of limestone and sandstone. Zone of *Ammonites angulatus*	*e.*
	1 foot of greyish-blue limestone, 1 foot " " " } Zone of *A. planorbis*........	*d.*
Junction-beds.	7 inches of bluish clay.	
	8 inches of light-blue sandstone with remains of *Vertebrata*, together with *Cardium Rhæticum*, *C. cloacinum*, *Schizodus cloacinus*, *Leda Deffneri*, *Avicula contorta*, *Mytilus minutus*, *Pecten Valoniensis*, &c. (Bone-bed.)........	*c.*
	6 inches of light-grey micaceous clay with fragments of coal.	
	6 feet of hard yellow sandstones........	*b.*
Keuper ...	Red Keuper marl	*a.*

Near Nürtingen, 5 hours (about 12 English miles) south-east of Stuttgart, the following series has been made out:—

Lias ...	Beds of clay, limestone, and sandstone. Zone of *Ammonites angulatus*	*e.*
	$1\frac{1}{2}$ to 2 feet of grey limestones with iron-ochre. Zone of *A. planorbis*	*d.*
Junction-beds.	4 inches of yellow clay.	
	1 inch to 2 inches of loose qaurtzose sands with traces of the Bone-bed	*c.*
	20 to 30 feet of fine-grained, yellowish-white sandstone, in its upper portion interspersed with galena and spheroids of hard sandstone... { 7 to 8 feet of non-fossiliferous sandstone. 3 feet of sandstone with casts of gasteropods (*Acteonina*, sp., *Nerita*, sp., &c.), *Anatina præcursor*, *Cypricardia Suevica*, *Neoschizodus posterus*, *Avicula contorta*, *Mytilus minutus*, *Gervillia præcursor*, *Lima*, sp., &c........ The inferior portion without organic remains.	*b.*
Keuper ...	Red Keuper marl	*a.*

Both sections show a certain number of constant horizons. The zone of *Ammonites Bucklandi* and *A. Conybeari* (not mentioned

* See Alberti, 'Monographie des Bunten-Sandsteins, Muschelkalks und Keupers.' 1834, p. 143; Murchison, 'Geol. of Cheltenham,' 1845, p. 55; Goldfuss, 'Petrifacta Germaniæ,' &c.

here) lies, in both localities, at a somewhat higher horizon. Below this zone comes *A. angulatus* with *Cardinia concinna, Chemnitzia Zenkeri, Turbo Philemon,* &c. Below this the zone of *Ammonites planorbis* is laid open in one or two calcareous beds. The strata which are the object of our investigation begin immediately below, and in the two sections given above they occupy different levels with respect to the important horizon of the Bone-bed.

Table of the Mollusca of the "Kössen-beds" in Suabia.

	Above, and with, the Bone-bed (Nellingen, Birkengehnen, &c.).	Below the Bone-bed (Nürtingen).	Other localities.
Acteonina, sp.*	....	scarce	Scesa-Plana (Vorarlberg)?
Anatina præcursor, *Quenst.* sp.	scarce.		
Cardium Rhæticum, *Merian*	scarce	....	Kössen Strata in the E. Alps.
Cardium cloacinum, *Quenst.*	frequent.		
Cypricardia Suevica, *Opp. & Suess*	....	scarce.	
Leda Deffneri, *Opp.*	scarce.		
Neoschizodus posterus†, *Quenst.* sp.	....	scarce	Kössen Strata of Scesa-Plana?
Schizodus cloacinus, *Quenstedt*‡, sp.	very frequent.		
Avicula contorta, *Port.*	very frequent..	very frequent..	Kössen Strata of the E. Alps Ireland
Gervillia præcursor, *Quenst.*§ sp.	...... ?	very frequent.	
Mytilus minutus, *Goldf.*‖	frequent	frequent.	
Pecten Valoniensis, *Defr.*	very frequent..	very frequent..	Kössen Strata of the E. Alps; Ireland; France.

In the former of these localities the shells lie immediately beneath the zone of *Ammonites planorbis,* in a sandstone-bed from 3 to 10 inches thick, at the base of which the Bone-bed is developed, as at

* The internal cast here alluded to may possibly belong to the species, from the Eastern Alps, identified with *A. alpina,* Klipst. sp., by M. Merian (Escher, "Vorarlberg," p. 19).

† Prof. Quenstedt is right in remarking the striking similitude of this species to *Trigonia curvirostris,* Goldf., occurring in the Muschelkalk, and which Prof. Giebel has recently taken as the type of his new genus "Neoschizodus" (Verstein. v. Lieskau, p. 39). This species is at present only known by some small indistinct internal casts, and by a larger cast, perhaps the original of Professor Quenstedt's figure (tab. 1. fig. 3).

‡ *Opis cloacina,* Quenst. We think that the systematic position of this small shell is not yet sufficiently cleared up, but at all events it seemed to us to be wrongly placed in the genus *Opis.*

§ Some specimens show feeble radial striæ. It bears some affinity to *G. substriata,* Cred. (Leonhard und Bronn, "Jahrbuch," 1851, p. 621. pl. 7. fig. 7).

‖ See Goldfuss, "Petrifacta Germaniæ," pl. 130. fig. 6; Alberti, "Monogr. d. Trias," p. 153; Quenstedt, pp. 29, 31. pl. 1. figs. 14, 36. The locality is erroneously spelt by Goldfuss: it is "Täbingen," and not "Tübingen."

Neuhausen on the Fildern, and on the Birkengehnen near Esslingen. Sometimes isolated teeth and bones are associated with the shells, *e. g.* at Nellingen, 2½ English miles south of Esslingen. In the second, the shell-bed lies 7 to 8 feet below the Bone-bed, especially near Nürtingen. The Table at p. 4 gives a synoptical view of all the molluscous remains hitherto found in these deposits.

Besides the species quoted in this Table, Prof. Quenstedt notices some others, which we think are still very imperfectly known: among them are *Venericardia præcursor,* Quenst. (perhaps identical with *Cardium Austriacum,* Hauer, if we may judge from some casts before us), *Plagiostoma præcursor,* Quenst., and a *Lima,* only known at present by internal casts,—at least we are not acquainted with the form of its external surface. We have not yet found in the deposits in question the *Mya mactroides,* Schloth., quoted by Alberti (Monogr. der Trias-Format. p. 153), nor the *Monotis inæquivalvis,* Bronn. *Pecten Valoniensis* and *Cardium Rhæticum* have not yet been found below the Bone-bed, so that *Avicula contorta* is the only form yet ascertained to be common to this lower deposit and to the Kössen beds.

M. Alberti was the first (1834*) in Wirttemberg who noticed these beds with regard to their fossil remains, describing them under the name of "Täbingen Fossiliferous Sandstone†." This distinguished geologist expressly mentions (*loc. cit.* p. 152) the simultaneous occurrence of teeth, bones, and shells in a fine-grained sandstone on the superior limit of the Keuper. The other localities have been brought to light by the successful investigations of M. Deffner, the owner of a manufactory at Esslingen.

These shelly deposits have not yet been found in every locality of Suabia where the boundaries of the Keuper and the Lias have been laid open. The sandstones are either so hard that nothing except carbonized vegetable remains can be got out of them, or they are reduced to siliceous bands, not above an inch in thickness, overlying the marls of the Keuper, and including the Bone-bed. The Lias appears immediately above them; and below them is a thin layer of grey clay imbedded in the red marls of the Keuper.

Similar circumstances are observable in many localities in France and England, where the beds intercalated between the Lias and the Keuper are laid open; in some of them shell-banks (generally composed of Pectens) seem to make their appearance‡. This similitude is still more striking in the Irish deposits, described by Col. Portlock§, containing *Pecten Valoniensis, Avicula contorta*, and a *Car-*

* "Beitrag zu einer Monographie des Bunten-Sandsteins, Muschelkalks und Keupers." Stuttgart, 1834.

† The same beds, with the same shells, occur at Täbingen, between Rottweil and Balingen.

‡ See Strickland (Proc. Geol. Soc. vol. iii. pp. 585 & 732; and vol. iv. p. 17); and Murchison (Geol. of Cheltenham, 1845, p. 54).

§ Geol. Report on Londonderry, &c., p. 90. We have previously had occasion to notice this concordance (Oppel, "die Juraformation, &c." pp. 16–24). Prof. Quenstedt ("Der Jura," pp. 25–31) has recently put forth the same opinion, without, however, duly attending to the very essential difference between "Lower St.

dium, identified by the describer with *C. striatulum*, Sow., but probably answering to *C. Rhæticum*, Merian. Wherever molluscous remains are wanting, the widely-spreading and easily recognizable Bone-bed* offers a safe horizon; and, even if this bed be not discernible, the limestones with *Ammonites planorbis* may be sufficient for obtaining at least an approximative parallelism. Even if the new and imperfectly preserved forms of mollusks occurring in these strata associated with the Bone-bed of Suabia, and provisionally designated as "Junction-beds," be left out of the question, we find contained in them three very characteristic species, which can scarcely be misunderstood: *Cardium Rhæticum, Avicula contorta*, and *Pecten Valoniensis*, none of them having been hitherto found in any horizon much above or below the beds in question. Their appearance in Suabia, near the shores of this ancient sea, in rocks bearing all the characters of littoral deposits, becomes still more interesting by the following considerations.

The Kössen beds near Vienna, and even considerably farther westward, at Kössen, and in the Bavarian Alps, are characterized by an abundance of Brachiopods, by large species of *Lima*, by *Ostræa Haidingeri, Gervillia Schafhautli*, and *G. inflata*, while *Cardium Rhæticum, C. Austriacum, Pecten Valoniensis*, and *Aviculæ* are but of scarce occurrence in the Brachiopod-limestones, although extremely abundant in isolated layers imbedded in the true "Dachstein Limestone†."

In the Vorarlberg the Brachiopods evidently become scarce, while the individuals of *Plicatula striata*, of *Cardium*, and of the curved forms of *Avicula* increase in number; now and then remains of fishes and *Bactryllia*‡, unknown in the Eastern Alps, are mingled with the shells.

An isolated layer of black slate, with numerous shells of *Avicula contorta, Cardium Valoniense*, and *Gervillia Schafhautli*, but without any Brachiopods, is imbedded in the Dachstein limestone of Stallehr, near Bludenz; while the Avicula-beds of Salzburg and Tyrol are generally white limestones, containing isolated Brachiopods§.

We may perceive in the Kössen beds, by following them from east to west, a gradual diminution, and at last a total disappearance, of *Brachiopoda* and other forms living in deep seas, together with a gradual increase, and finally a prevalence, of other shells almost exclusively belonging to the *Pectinibranchiata*.

Cassian" and "Upper St. Cassian" (Kössen beds). We are not aware that a single species from the deposits in question occurs at St. Cassian itself.

* On its extent and constitution, see Quenstedt (Das Flötzgebirge Wirttembergs, p. 110); Oppel (die Juraformat. Engl. Franckr. u. des südwestl. Deutschl. 1856, pp. 16–24); Marcou, "Sur le Jura Salinois" (Mém. de la Soc. Géol. 1848, vol. iii. p. 32); Strickland, *loc. cit.*

† See Hauer (Jahrbuch der K. K. Geol. Reichsanstalt, 1853, p. 729); Suess, "Brachiopoden d. Kössner Schichten" (Vienna Academy Memoirs, vol. vii., and Q. J. G. S. vol. xi. part 2. p. 26). For the present we leave unnoticed the strata of Euzesfeld.

‡ These fossils seem here to act the same part as do the small capsules of plants in the older and extensive bone-bed of Ludlow. See Hooker (Quart. Journ. Geol. Soc. vol. ix. 1853, p. 12); and Murchison (Siluria, p. 237, &c.).

§ See Peters (Jahrbuch der K. K. Geol. Reichsanstalt, *loc. cit.* p. 185).

The fauna of the Suabian sandstones in question furnishes the concluding link of the geological chain; and we do not hesitate to assert that the question, whether the Kössen strata are to be ranked with the Lower Lias, or with the St. Cassian deposits, cannot be decided without coming to the same result with regard to the Bone-bed; and that the Mammalian remains of the Bone-bed belong to the same epoch as the Kössen beds of the Eastern Alps.

On the Tertiary Deposits *of the South-east of* Carinthia. By M. Lipold.

[Proceed. Imp. Geol. Instit. Vienna, January 29, 1856.]

This district was visited by M. Lipold in the summer of 1855. The "diluvium" lies along the whole course of the River Drave, from the Rosenthal to Drauburg, where the river leaves the Carinthian territory; it extends also over the wide plains of the Jaun valley. Less extensive deposits are met with in the Vellach and Miss valleys. In the lower portion of the valley of the Drave, the diluvium attains a thickness of 300 feet; and is composed of gravel and conglomerates, clay appearing in some few isolated localities only. Near Pereschitzen the diluvium or drift is overlaid with extensive layers of calcareous tuff, used for building-purposes.

The Tertiaries form a nearly continuous range of hills, running E. and W., along the northern foot of the Carinthian limestone-mountains, from the Rosenthal to the frontier of Styria. Some few isolated deposits of the same period occur within the region of the calcareous Alps. On the right bank of the Drave and in the Jaun valley, the tertiaries assume almost exclusively the character of conglomerates, lying horizontally on the base of the calcareous mountains, or rising in isolated hills amidst the plains of drift. They may be regarded as a continuation of the Turia and Satnitz tertiaries on the left of the Drave, which has broken through these strata, having on both its banks highly picturesque perpendicular cliffs.

The average thickness of the conglomerates is 600 feet: on the calcareous rocks of the Rosenthal rolled fragments of the tertiary deposits are found at 3600 feet above the valley; and near Windisch-Bleiberg the tertiary conglomerates reach an elevation of 4000 feet above the level of the Adriatic.

The older tertiaries, consisting of sands, sandstones, and plastic clay, are rarely exposed in the region above described, but prevail towards the east, and are everywhere more or less lignitiferous. Near Unterorl five beds of lignite, of from 1 to 2 feet average thickness, have been opened in a deposit of plastic clay, containing in its sandy portions *Helix inflexa*, Martens, which also occurs in the Neogene freshwater strata of Steinheim, Wirttemberg. The tertiary beds of Unterorl trend from N.W. to S.E. with a slight dip to the S.W.

The tertiary deposits of Missbach are separated from the above-mentioned by a great mass of the Gailthal (carboniferous) strata. Their lignitiferous portion has a total thickness of from 6 to 7 feet, the beds of lignite varying from $\frac{1}{4}$ to 1 foot.

The tertiary basin of Liescha, south of Prevali, extending in an east and west direction and entering the Styrian territory, is far more important than either of the preceding groups. It lies from 500 to 600 feet above the level of the Miss valley, near Prevali, being separated from it by micaceous schists associated with eruptive porphyries. The Liescha basin is bounded on the north by mica-schist; on the south by the Gailthal (carboniferous) rocks. The descending order of the strata is:—1. calcareous breccia; 2. rolled fragments of limestone; 3. argillaceous sand with freshwater molluscs; 4. sandstone and conglomerate; 5. yellow sands with patches of coal; 6. grey clay with vegetable remains; 7. upper bituminous clay, with some subordinate lignite-beds; 8. principal lignite-bed; 9. bituminous clay; 10. white clay.

The vegetable remains have been described by Prof. Unger in the Imp. Acad. Proceedings, Nov. 1855. Dr. Hoernes has found among the molluscs *Melania turrita*, Klein, and *Helix Steinheimensis*, Klein, both species occurring in the Neogene freshwater limestone of Steinheim and Zweifalten.

The main lignite-bed has an average thickness of 18 feet, and diminishes gradually, apparently disappearing with the increase of depth. The strike is to the eastward, with some slight deviation; and its dip is south at an angle of 15° diminishing gradually to 8°.

The workings now opened to the length of 3600 feet, and to an extent of 1800 feet along the dip, show that these strata do not occur in the form of a basin, as they do not ascend along the south mountain-slope. The present produce, 840 workmen being employed, amounts to more than 1,000,000 cwt. annually, and is consumed in the extensive puddling and rolling establishments of Prevali.

[COUNT M.]

On HARTITE. By M. VON ZEPHAROVICH.

[Proceedings Imp. Geol. Instit. Vienna, Feb. 12, 1856.]

THIS resinous substance was first discovered by Haidinger in the upper zone of the lignites at Ober-Hart, near Gloggnitz, in Lower Austria. The hartite found at Rosenthal, near Köflach (Styria), is in comparatively large, irregular, perfectly transparent, and cleavable pieces, showing in the tourmaline of the polarizing apparatus very distinct systems of elliptical coloured rings. It is still more frequently found within the lignite in the form of small veins, incrustations, or angular fragments. The microscopic crystals deposited from an alcoholic solution of hartite are in the form of rhombohedral and hexagonal lamellæ, the angles of which, according to Prof. Kenngott, correspond with those found by M. Haidinger in the lamellæ obtained by cleavage. [COUNT M.]

On the Geology of parts of the Tyrol *and* Vorarlberg. By M. Gümbel.

[Proceedings Imp. Geol. Instit. Vienna, Feb. 12, 1856.]

M. Gümbel's observations relate to the geology of the portion of Tyrol and Vorarlberg included between the valley of the Rhine, the crystalline slates of the principal Alpine zone, the Kaiserpass, and the Bavarian frontier. M. Gümbel has paid particular attention to the "Flysch" and its analogues. He recognizes in the Flysch of the Vorarlberg four well-characterized divisions. The first of them, called by him the "Inferior Alpine Slate," lies between the Verrucano and Liassic Dolomite; it belongs to the Triassic epoch, and contains no other fucoids except the well-known *Halobea Lomeli*: gypsum, anhydrite, and rock-salt are imbedded in it. The second, M. Gümbel's "Allgau Slate," immediately overlies the Adneth Limestone; its fucoids, although similar to those of the Eocene Flysch, are specifically different from them: it contains Liassic Cephalopods, as *Ammonites radians, A. Amaltheus*, &c. The spotted or Amalthean Marls belong to this division. The third division is a Nummulitic Flysch, comprising argillo-calcareous marls, with chert and glauconite, alternating with nummulitic beds. The fourth division ("Intricati Flysch") with *Chondrites intricatus, C. furcatus*, &c., which covers the nummulitic strata, must be considered as a deposit of the second Eocene period.

[Count M.]

On the Metalliferous *and* Porphyritic Veins *of the* Erzgebirge. By Baron de Beust, Chief Director of the Mining Department in the Kingdom of Saxony.

[Proceedings Imp. Geol. Instit. Vienna, Feb. 12, 1856.]

The subject of this communication is the metalliferous veins of the Saxon Erzgebirge, with respect to the porphyry-veins associated with them. Baron de Beust thinks that the phænomena of the diffusion of metalliferous minerals in the region in question, and generally through the whole of Europe, may be grouped under some few very simple laws. Four lines of elevation may be distinguished in the metalliferous mountains of Saxony and North-west Bohemia,—namely, the Erzgebirge line (W. to E.), the Sudetian line (W. to E. or more exactly 300° to 120°), the Böhmerwald line (345° to 165°), and a fourth line (S.W. to N.E.). The porphyry-veins in Saxony and in the adjacent countries run in a direction conforming to one or other of these four lines; the more important of them, which are connected with the carboniferous basins of Saxony, offer a remarkable parallelism with these lines; and the same circumstance may be observed in the direction of the metalliferous veins in the Erzgebirge, especially in those of the Freiberg district, so that both porphyritic and metalliferous veins may be correctly admitted to stand in the mutual relation of cause and effect. Baron de Beust points out the practical value of these theoretical laws, as giving sure indications of the presence of useful minerals. Thus, for example, the whole of that portion of Saxony which is traversed by porphyritic veins may, with good reason, be supposed to be more or less metalliferous. The existence of an extensive coal-basin beneath the porphyry between Grimma and Rochlitz is very probable, and even the porphyritic rocks of the Tharand Forest and of Meissen may be presumed to be connected with carboniferous deposits.

From the distribution of metalliferous veins in Saxony the author passes to their distribution through the whole of Europe. He distinguishes three principal metalliferous zones, following in their general direction the Erzgebirge and Sudetian lines. The first of these zones runs from the shore of the Black Sea in Bessarabia, through Moldavia, Bukowina (East Gallicia), North Hungary, Upper Silesia, Saxony, the Hartz, the Teutoburg Forest, and, beyond the English Channel, through the extensive lead-districts of Derbyshire and Cumberland. The second seems to begin on the shores of the Atlantic near Lisbon, and passes across Spain, Southern France, Upper Italy, Illyria, Carinthia, Banat, and Transylvania. If this direction be correct, it must intersect the first line in the Caucasus; and this group of mountains may then be supposed to contain an enormous store of metalliferous minerals. This supposition is in some measure supported by the observations of M. Czarnotta, an Austrian mining-officer in the Persian service, who describes the Zend mountains near Tabriz as being uncommonly metalliferous, and the chain between Sultania and Kasbin as being a continuous and enormous mass of iron-ore. The third zone, of a breadth of eighty to ninety German (about 400 English) miles, begins in North-west Spain, passes through Bretagne, the smaller Channel Islands, South Belgium, Nassau, Westphalia, the Erzgebirge, and the Hundsdruck, and intersects the first zone very near the metalliferous districts of Saxony.

Baron de Beust concludes by pointing out the curious circumstance of the Saxon stanniferous zone lying in the same straight line with the tin-deposits of Limoges and of North-west Spain, in the same manner as a line drawn through the quicksilver-deposits of Spain and Tuscany, if lengthened, will pass through Idria, and end in the veins of mercurial grey copper in Upper Hungary.

Haidinger noticed in 1849 an analogous circumstance with regard to boracic acid; all the localities where this acid is found, either free or combined with basic substances (forming Sassoline, Boracite, and Latolite), being situated along the same north and south line, traceable from the Isle of Vulcano (Lipari Islands) to Arendal in Norway, and sending a westerly branch from Arendal, through Utöen, to Salisbury Crag, near Edinburgh.

[Count M.]

On the Lignite Basin *of* Falkenau *and* Elbogen, *in* Bohemia. By Dr. F. Hochstetter.

[Proceedings Imp. Instit. Vienna, Feb. 19, 1856.]

This basin, 3 Austrian miles in length and 1½ in breadth, lies in a depression between the Carlsbad Mountains and the Erzgebirge, and is really the central portion of the Egra basin, being separated from the upper basin by the mountain-range of Maria Kulm, and from the lower one by the basaltic rocks near Saatz and Teplitz. The basis of the lignitiferous deposits consists of loose sandstones, conglomerates, and quartzose sandstones (with siliceous cement of extraordinary coherence), appearing in some localities only in the form of blocks. Near Altsattel the sandstones, which attain a thickness of 100 feet, contain numerous vegetable remains, including Palm-leaves. These sandstones are overlaid by clays, 10 to 20 feet in thickness, some plastic, others sub-schistose, varying greatly in colour, and in some localities pyritiferous enough to serve, on a large scale and with great advantage, for the manufacture of sulphur, alum, sulphate of iron, and sulphate of copper. The clays include numerous beds of good lignite, and sometimes of excellent glance-coal. These lignitiferous deposits are disturbed, broken, and dislocated in their stratification. They are of ante-basaltic date, while similar post-basaltic deposits overlie them in horizontal and undisturbed stratification. The erupted basalt of North-west Bohemia occurs between these two deposits. The superior post-basaltic division is characterized by beds of basaltic tuff, thick beds of lignite of inferior quality, finely laminated, tough shales (with remains of insects and vegetables), limestones (with *Helices*) and quartz-rock (both the latter of freshwater origin), and by an abundance of hydrous oxide of iron and sphærosiderite, distributed in the uppermost ferruginous clay. Kaolin-deposits occur at Zettlitz, near Carlsbad, and at many other localities; they seem to be local results of the decomposing action of tertiary waters on the granite beneath. Porcellanous jasper and bacillary iron-ores, &c., the ordinary products of the spontaneous combustion of the lignite-beds, occur around Carlsbad and Falkenau.

The distinction of ante-basaltic and post-basaltic deposits in the lignite-basin of Elbogen leads to a geological question of general interest. The ante-basaltic deposits occur not only at the bottom of the basin, but on the slopes and even on the tops of the neighbouring mountains, as high as 2100 feet above the level of the sea, where they are overlaid by basalt, and where the lignites are still worked for fuel. The post-basaltic beds occur exclusively within the basin itself. These circumstances indicate considerable disturbances connected with the basaltic eruptions, which are generally explained by supposing a last and general upheaving of the Erzgebirge and the Carlsbad Mountains, posterior to the lignite-period. Dr. Hochstetter is of opinion that both these mountain-chains occupied their present level long before this period, and that the immense basaltic masses of Duppau and of the Mittelgebirge by their outburst broke the connecting link between the Erzgebirge and the Carlsbad Mountains, and caused it sink to a lower level. The first tertiary deposits covered the flattened mountain-tops, the succeeding ones were deposited in the basin formed by the breaking down of the older rocks. Traces of this catastrophe may be seen in the violent dislocations of the lower lignitiferous deposits, and in the great precipices existing around Carlsbad.

[Count M.]

On the Mountain Limestone *and* Old Red *of* Britain. By Prof. De Koninck.

[Proceed. Imp. Geol. Instit. Vienna, Feb. 19, 1856.]

M. von Hauer communicated a letter from Prof. De Koninck, in which he states that he has succeeded in tracing in the Carboniferous formation of England and Scotland two quite different faunæ, the one corresponding to the carboniferous fauna of Visé and Bleiberg, the other to the fauna of the Tournay coal-basin. These two faunæ, although contemporaneous, are nowhere found co-existent.

Prof. de Koninck thinks that the Old Red Sandstone of England and Scotland, supposed to belong to the Devonian system, is in reality the base of the carboniferous group; a circumstance without analogy in the rest of Europe.

[Count M.]

Additional Information respecting the Mayence Tertiary Formation. By Prof. Frid. Sandberger.

[Leonhard und Bronn's Neues Jahrbuch für Min., &c. 1856, pp. 533–536.]

M. Weinkauff, of Kreutznach, has forwarded to me for examination the fossils which he continues to collect from the coarse-grained marine sand of that neighbourhood. The sand is generally cemented together by barytes. Although these fossils are merely casts or impressions, often consisting of pure barytes, they can nevertheless be accurately determined chiefly by comparison with the well-preserved remains of Weinheim and Alzey. The following list will show that the result gives a much greater abundance of species than was hitherto suspected, as well as local divergences from Weinheim, particularly in the abundance of several species. Moreover two specimens of *Cerithium margaritaceum* were for the first time found in the lowest bed of the basin, this fossil being one of the most common in the upper bed. Altogether I have found the following:—

Fossil-wood and Cones, both derived from *Coniferæ*.

Corals, identical with the *Thecosmilia* found in badly preserved fragments at Weinheim.

Ostræa callifera, *Lam.*, generally smaller than at Alzey.

Pecten pictus, *Goldf.*

Pecten furfuraceus, *A. Braun.*

Chama exogyra, *A. Braun.*

Pectunculus crassus, *Phil.*

Pectunculus arcatus, *Schloth.*
Limopsis Goldfussi, *Nyst.*
Arca hiantula, *Desh.*
Modiola sericea, *Br.*
Diplodonta fragilis, *A. Braun.*
Lucina tenuistria, *Héb.*
—— Bronni, *Mer.*
Cardium tenuisulcatum, *Nyst.*
—— scobinula, *Mer.*
Cyprina rotundata, *A. Braun.*
Isocardia transversa, *Nyst.*
Cytherea splendida, *Mer.*
Cardita orbicularis, *Br.*
Corbula pisum, *Sow.*
Thracia phâseolina, *Kien.*
Tellina Hebertiana, *Bosq.*
Teredo anguinus, *Sandb.**, boring fossil wood.
Dentalium Kickxi, *Nyst.*
Vermetus, sp.
Tornatella Nysti, *Duch.*†
Trochus Rhenanus, *Mer.*
Xenophora Lyellana, *Bosq.*
Natica glaucinoides, *Sow.*
Cerithium margaritaceum, *Lam.*
Tritonium Flandricum, *De Kon.*
Murex Deshayesii, *Duch.*
Voluta Rathieri, *Héb.*
Chenopus acutidactylus, n. sp., identical with one of the forms from Alzey.
Cypræa, sp.

The following are very common, *Pectunculus, Natica glaucinoides, Lucina tenuistria, Dentalium Kickxi, Xenophora Lyellana,* and *Ostræa callifera*; whereas *Natica crassatina, Perna,* and Shark's teeth are altogether wanting. M. Weinkauff is still collecting in other portions of the district hitherto neglected, and I therefore look forward to another early opportunity of completing the fauna of the marine sands of each separate locality.

It is most satisfactory to know, from information recently received from him, that M. Deshayes is about to publish a Supplement to his valuable work "On the Shells of the Paris Basin," in which he will make known the new discoveries in the *Sables Supérieurs* near Jeurre, Etampes, &c., the fauna of which is almost identical with that of Alzey; we shall then be the more convinced that this formation is spread over vast districts. Its extension from Kreutznach to the Solothurn Jura (Delsberg), although with considerable gaps, imparts to it a more than common interest.

According to communications received from Prof. Emmrich, I have no longer any reason to doubt that the so-called shell-molasse of the Chiemsee, in the neighbourhood of Traunstein and other localities in the highlands of Bavaria, also belongs to this formation; and Emmrich has lately distinctly stated‡ that this formation occurs above the nummulitic beds, and under the Cyrena-marls with pitch-coal of Miesbach, which are absolutely identical with our Rhenish Cyrena-marls. There is no longer any question of a comparison with the true Upper Miocene molasse of Switzerland (St. Gall). And thus we also find along the edge of the Alps intermediate formations between Eocene and Upper Miocene, as everywhere else in the true typical development of the whole formation.

In the sandstones of the Chiemsee, of the Lochergraben near

* Numerous specimens, of all ages, of this species were lately found at Alzey by M. Grein, and will shortly be described by me. Its nearest analogue is *Teredo Tournali*, Leym., from the nummulitic beds.

† By comparison of the Mayence species with the true *T. simulata*, Brand., which I have received from Mr. Hamilton, I have convinced myself that they are different species. The Magdeburg species is, again, different from that of Mayence or London. The same may be said respecting the supposed identity of *Tritonium argutum* and *T. Flandricum*, as Beyrich has already suggested.

‡ Zeitschr. Deutsch. Geol. Gesells. vol. vi. p. 668.

Miesbach, and of the neighbourhood of Traunstein, which Emmrich forwarded to me, I found—

Lamna contortidens, *Ag.*
Panopæa Hebertiana, *Bosq.*
Ostræa cyathula, *Lam.*
Ostræa longirostris, *Lam.*
—— ventilabrum, *Goldf.*
Pleurotoma laticlavium, *Beyr.*

all of them true lower Miocene forms, amongst which *Ostræa cyathula,* as a widely extended typical shell, is of great importance; the other fossils, with the exception of the *Echinus* described by Schafhäutl, were too ill preserved to allow me to pronounce positively respecting them. The Cyrena-marls which overlie this formation produced on the other hand—

Cyrena subarata, *Br.*, forming whole beds.
Tichogonia Brardi, *Desh.*, partly with remains of colour.
Cerithium margaritaceum, *Lam.*
Cerithium plicatum, *Lam.*, especially var. Galeotti, *Nyst.*
Melanopsis prærosa, *Lam.*
Planorbis ? declivis, *A. Braun.*
Cytheridea Mulleri, *Münst.* sp.

A plant not to be distinguished from *Cupressites freneloides,* Ettingsh., was found in the clay of the Grossthal beds; the pitch-coal of the Peisenberg and of the Leiznachthal beds contained remains of flattened *Planorbes,* and *Helices,* one large species of which was ribbed, entirely corresponding with *H. Ramondi,* and a *Unio* which could not be accurately made out. My above-mentioned statement appears therefore to be sufficiently confirmed.

The position of the Septaria-clay and of the Cyrena-marl has occasioned a discussion between Prof. Beyrich and myself. I now believe, according to the recent discoveries near Cassel (Hesse), that the Septaria-clay there overlies the representatives of the Cyrena-marl or the lower brown-coal formation, the fossils of which have been described by Dunker*. It is thus admitted that it is somewhat younger, but certainly not much, as fossils of the Septaria-clay occur partly in the marine sands of Alzey, and partly in the Cyrena-marl. It would thus, as the deposit of a true saline northern ocean, belong to about the same age as the brackish Cerithium-limestone of the Mayence basin, but by no means younger than the upper deposits of this basin, as Beyrich supposed, probably because he referred all the brown-coals of Cassel to the same age. It has, however, now been shown that the occurrence of the not very uncommon *Leda Deshayesana* with shells of the Cyrena-marl near Selgen, in Rhine Hesse, which were supposed by my late friend Voltz to be in a primary position, are in a secondary one, *i. e.* that the bed containing the fossils is a pebbly diluvial loam. Now as *Leda Deshayesana* has been found near Mosbach, not far from Wiesbaden, in the diluvium accompanied by tertiary fossils from very different beds, my former opinion of its occurrence *in situ* in the Mayence basin in its original or primary deposit must be modified. It rather appears to have been washed into the basin during the diluvial period from deposits of Septaria-clay situated further north, and to have become mixed up with the fossils washed out of the upper beds of the underlying tertiary formation. Nevertheless, however, many other fossils undoubtedly

* Programme of the Upper Trade Schools at Cassel, 1853, p. 4.

characteristic of the sand of Alzey (*Chenopus speciosus, Pleurotoma,* &c.) and of the Cyrena-marls prove the close connexion between these formations. Respecting other tertiary formations, particularly those of Baden, I hope soon to make some further communications.

[W. J. H.]

On the METALS *and* MINES *of* NORTH-WESTERN BOHEMIA. By M. JOKÉLY.

[Proceed. Imp. Geol. Instit. Vienna, April 1, 1856.]

THIS communication comprises a general survey of the metallic products and mining operations in the Bohemian portion of the Erzgebirge, the Fichtelgebirge, the Kaiserwald, and the northern extremity of the Böhmerwald. The metals occurring in this district are silver, uranium, nickel, bismuth, cobalt, lead, zinc, copper, iron, manganese, and tin. The ores of this last metal, geologically speaking the most important of the whole, are intimately and, it seems, necessarily connected with granite; as, when they occur in crystalline rocks, they are only abundant where those rocks come in contact with granite. The tin-mines in the district in question were in existence as early as the twelfth and thirteenth centuries, and attained their full development in the sixteenth century. Subsequent wars and calamities caused their gradual decay, so that at the present time the workings are confined to five localities. Two systems may be distinctly traced among the stanniferous veins; as one of them crosses the other they are consequently of different age.

Silver, nickel, bismuth, cobalt, and uranium are now the most important objects of mining-industry within the district in question, the centre of which is at Joachimsthal. At this place mines have been open ever since the beginning of the sixteenth century, and still promise a long and prosperous exploitation*.

The veins of ores of the above-mentioned metals, which are contained both in mica-schist and in primitive clay-slates, extend into the neighbouring mountains of Saxony. They may also be divided into two groups; the one running from south to north; the other from west to east, and cutting across those of the former group. About a hundred and fifty of these veins have been opened for exploitation within the mining-district of Joachimsthal.

The argentiferous veins are but of subordinate importance in the slates to the west of the Eibenstock-Neudeck granites. Lead- and copper-ores, formerly worked on a large scale, are more developed in the primary clay-slate of this locality: the exploitation of lead is now confined to the Bleistadt-Prünlass district. The veins run from south to north and from west to east, and are contained in mica-schist near its line of contact with clay-slate; they contain galena, iron-pyrites, sulphide of zinc, and brown phosphate and white carbonate of lead; green phosphate of lead was formerly found in them. Some other lead-mines are also worked in mica-schist. Those in clay-slates are insignificant, on account of the poverty of their ores. Beds of sul-

* See Quart. Journ. Geol. Soc. vol. xii. part 2. Miscell. p. 6.

phide of zinc, more than a fathom thick, accompanied by magnetic iron-ore, oxide of zinc, and iron- and copper-pyrites, and associated with crystalline limestones and diorites, occur under particular circumstances, analogous to those observed at Breitenbrunn and Rittersgrün (Saxony) in the clay-slate of Goldenhöhe.

Near Neudeck two veins of magnetic iron-ore, associated with eclogite, and running from south to north in granite, are now being worked. The thickness of that portion of them which is metalliferous varies from 5 to 7 fathoms. Quartz-veins with red oxide of iron, traversing an eclogitic rock, are worked near Hochofen. The same iron-ore occurs in other localities of the mica-schist district, associated with amphibolic and dioritic rocks.

The numerous veins of quartz, which are rich in red and specular oxide of iron, and run from north to south through the granite and the crystalline slates, may be considered to be a special system, later in age to all the other metalliferous veins of the country under notice. These veins are here and there associated into groups, and extend into Saxony; two of them (the Irrgänger and the Hemecberger Zug) having a total length of from 4½ to 5 Austrian (or from 22 to 25 English) miles: sometimes ores of manganese (pyrolusite, polianite, and psilomelane) abound more than the iron-ores, and even totally replace them.

The Bohemian portion of the Fichtelgebirge and the Kaiserwald (Carlsbad Mountains) are metalliferous in a lesser degree than the Bohemian Erzgebirge and the Bavarian portion of the Fichtelgebirge, whence gold, silver, and tin were formerly obtained. Traces of gold and silver have been found, but were soon neglected. Some tin- and cinnabar-mines were also long ago abandoned; and at the present time beds of oxide of iron, contained in clay-slate, are the only object of mining-operations in this part of Bohemia. During the sixteenth century ores of silver and lead were worked in the Kaiserwald; at present the only objects of mining-industry are some quartz-veins near Reichenbach, running N.E. and S.W., and containing galena with pyrites and sulphide of zinc, and also a deposit of red oxide of iron near Schönficht. Some years ago tin-ores in granite, under circumstances similar to those observed in the Erzgebirge, and ores of cobalt and manganese were worked in the environs of Königswart.

The northern extremity of the Böhmerwald, where, in the sixteenth century, there were extensive gold, cobalt, silver, and graphite mines, has now lost the better part of its metallurgical importance; there existing only some isolated and minor exploitations of copper-ores, galena, and oxide of iron.

The mining-activity of these districts, although it has sensibly fallen off from its former prosperity, may still, however, be revived, as the old workings have only exhausted the upper horizons of the metalliferous deposits, without penetrating into their depths, which may reasonably be supposed to contain undiscovered riches. The revival of mining-operations would be a real benefit to the inhabitants of these districts, as they are deprived of every other means of existence. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

ANALYSIS *of some* ASPHALTIC SLATES *and* LIMESTONES *from* SEEFELD *in the* TYROL. By M. KRAYNAG, Manager of the Saltworks of Halle.

[Proceedings Imp. Geol. Instit. Vienna, April 8, 1856.]

THESE limestones contain from 7·28 to 7·71 *per cent.* of resinous substances soluble in alcohol, æther, and turpentine. A bituminous slate from Seefeld contained 13·01 *per cent.* of bitumen and 80·13 *per cent.* of carbonate of lime. The distillation of a resinous red asphalt-stone gave 14·3 *per cent.* of petroleum : a black variety of the same stone gave 20 *per cent.* The naphtha extracted from the Seefeld asphalt has a specific weight of 0·847 ; it is composed of Carbon, 80·73 ; Hydrogen, 11·07 ; and Oxygen, 8·19 *per cent.*

[COUNT M.]

On the NORTH-EASTERN ALPS. By M. STUR.

[Proceedings Imp. Geol. Instit. Vienna, April 30, 1856.]

M. STUR, having prepared a map of the Neogene, Diluvial, and Alluvial deposits in the N.E. Alpine territory, on which the Leitha-limestone, the freshwater deposits, the lignites, and the true brown-coal were distinguished, as well as the "Diluvial" terraces, levels, erratic blocks, and moraines, by peculiar tints, explained the indications of the successive disturbances of the Tertiary and Post-tertiary strata, the lines of which were also marked on the map. M. Stur's researches had led him to the following results. He considered that—1. An upheaval of the Alps, attended by great disturbance of the strata, took place after the deposition of the Eocene beds, and gave origin to the transverse Alpine valleys.—2. A subsidence took place after the plastic clay had been deposited; and another, to a greater extent, after the deposition of the sands.—3. Subsequently to the deposition of the gravels in the Alps and on the plains, the Alps were again upheaved, though not so forcibly as at the former period of upheaval.

The deposits of plastic clay, sands, gravel, and "diluvium" within and without the Alps are ascribed by M. Stur to the results of these changes in the level of the Alps and of the Tertiary sea surrounding them. It is impossible to identify the two subsequent upheavals of the Alps. The uprise of the strata of the Swiss molasse might be regarded as being probably contemporaneous with the great Alpine disturbances which brought the strata into a fan-like position, and might prove an argument in favour of a single great post-tertiary uprise of the Alps, were not this hypothesis completely refuted by the position of the neogene deposits in the north-eastern Alpine district. Here also mica-schist overlies the lias-limestone (Lienz in Tyrol),—the Vienna-Sandstone dips exclusively southward, seemingly beneath the Alpine Limestone,—Nummulitic sandstones dip beneath the Hippuritic limestones; but the neogene deposits rest in horizontal undisturbed strata on all these older formations.

Slight disturbances of the neogene strata occur in some few localities, but are not to be paralleled with the grand and nearly general disturbances to which the older rocks have been subjected. The disturbed condition and vertical faults of the neogene beds increase in frequency and importance from East to West. The second upheaval of the Alps, the traces of which are scarcely visible in the north-eastern part of the chain, but very considerable in the western portion, may therefore be supposed to have occasioned still greater disturbances at its western extremity, so that the uplift of the Swiss molasse may be conveniently identified with M. Stur's post-tertiary upheaval. Similar oscillations of the earth's crust have been observed in North America by Prof. Dana.

In a paper on the influence of the soil on the distribution of plants, which M. Stur published some time since in the Proceedings of the Vienna Academy*, he expressed his opinion that the physical geography of the Alps, and the successive development of vegetable life upon their surface, cannot be satisfactorily understood without an exact idea of the extent and the external constitution of this mountain-chain during the Neogene and Diluvial periods.

[COUNT M.]

On the HOLLOW PEBBLES *found near* LAURETTA. By Director HAIDINGER.

[Proceedings Imp. Geol. Instit. Vienna, July 24, 1856.]

THESE hollow pebbles were found by M. Haidinger near Lauretta, in the Leitha Mountains, on the Austro-Hungarian Frontier, and first described by him in August 1841. They are calcareous, of a dark-grey colour, much worn, from $\frac{1}{4}$ of an inch to 3 inches in diameter, and are conglomerated by means of a hard yellowish-white calcareous cement. Beds of this conglomerate, alternating conformably with sandstone and plastic clay, are not uncommon in the tertiary limestone, known as "Leitha-limestone" by the Vienna geologists, around Lauretta. At one place M. von Zepharovich found three of these beds, one above another, separated by different strata. Besides these calcareous pebbles, the conglomerate includes

* Sitzungsberichte, vol. xx. p. 71. See also Annals Nat. Hist. ser. 2, vol. xviii. p. 520.—EDIT.

rolled fragments either of Nullipores or of inorganic concretions, of hard limestone with Foraminifers, and of shells and other organic remains. The dark-coloured pebbles are more or less excavated; sometimes the interior has all gone, leaving only a thin husk. Some of the pebbles have quite disappeared, the space they once occupied being only left. In consequence of the schistose structure of their original rock, some of the pebbles present exfoliations. Sometimes their interior is occupied by an inconsistent light-grey nucleus, or with incoherent dust.

Ch. von Hauer, having submitted these pebbles to chemical analysis, found that the yellowish-white calcareous cement was nearly pure carbonate of lime, with only $\frac{1}{200}$ of carbonate of magnesia, $\frac{12\cdot9}{100}$ of insoluble residuum, and a trace of iron. A massive dark grey pebble gave carbonate of lime, 98·33, and carbonate of magnesia, 12·000 (both carbonates nearly in the mutual proportion of 6 to 1). This proportion is as 3 to 2 (carbonate of lime, 62·52; carbonate of magnesia, 36·75) in the dust contained in the cavities. This powdery substance, which is slowly soluble in, and feebly effervescent with hydrochloric acid, may be therefore considered as being of a dolomitic nature, and may be supposed to have remained after a part of the carbonate of lime had been dissolved by water saturated with carbonic acid, and again precipitated in a crystalline shape amid the surrounding cement.

[Count M.]

On the Geology *of the* Eastern Environs *of* Trente, *in the* Southern Tyrol. By Prof. Emmrich.

[Proceedings Imp. Geol. Instit. Vienna, November 11, 1856.]

The dolomite of Monte Calva and Monte Calis rests, in the Fersina Valley, on argillaceous slate and red Triassic sandstone, overlaid on the right side of the valley by thick bands of rolled pebbles, imbedding a stratum which contains impressions of dicotyledonous leaves. These dolomites are again overlaid by still thicker masses of light-coloured limestone, generally of a fine-grained oolitic structure, and alternating upwards with compact grey limestones; and downwards, with yellow and red limestones. Whole beds of these compact limestones are full of the "Dachstein-bivalve" [*Megalodon scutatus*, Schafh.], associated in one locality (between Civezzans and Cognola) with *Chemnitziæ*, 6 inches long, and large *Terebratulæ*, resembling *T. Grestenensis*, Suess, or *T. pyriformis*, Suess, in the wide rostral aperture. The same strata comprise marly beds full of small testacea, such as *Ostræa*, *Gervillia*, *Mytilus*, &c.

Prof. Emmrich infers from these facts, that the oolitic limestone, so much developed in the Alps of South Tyrol, is an equivalent of the Dachstein and Gervillia (or Kössen) strata of the Northern Alps. The oolitic limestones are succeeded by red jurassic, then red and white Diphya-limestones, containing teeth of *Sphærodus*, shells of *Terebratula diphya*, *Aptychi*, and remains of *Ananchytes*.

The grey and schistose marly limestones of Nousberg (between Trente and Gardolo) bear a striking resemblance to the Neocomian deposits of the North Alps; but have not yielded any fossils.

[COUNT M.]

On the IRON-DEPOSITS *of the* CIRCLE OF JASLO, *in* GALICIA. By M. LIPOLD.

[Proceedings Imp. Geol. Instit. Vienna, Nov. 11, 1856.]

THE southern portion of this part of Galicia, as far as the frontier of Hungary, consists of low hills, having, on an average, an altitude of 2800 feet above the Adriatic, and belonging to the Beskid subdivision of the Carpathian chain. The sandstones and calcareous and argillaceous marls and shales which compose it belong to the Upper Carpathian Sandstone, corresponding to the Upper Cretaceous group. The general strike of the beds is N.W.–S.E., and their dip S.W.

The iron-bearing rocks in the territory are analogous to those known in the more distant W. and E. portions of the Carpathians of Galicia. Two ferriferous zones, striking and dipping parallel to each other and to the imbedding strata, may be distinguished; and a mass of white quartz-sandstone, about 1000 feet thick, is intercalated between them. The outcrop of one of these zones is known along a line of 5 Austrian (about 25 English) miles; that of the other, for about 4 Austrian miles (about 20 English). Both are composed of a series of inch-thick layers of iron-ores, alternating with sandstones, marls, and shales.

The ores are clay-iron-stones and sphærosiderites, with from 18 to 36 *per cent.* of metallic iron. The highest amount of raw iron extracted from them by metallurgical operations is 29 *per cent.*

[COUNT M.]

On some FOSSILS *from* RAIBL *in* CARINTHIA. By FR. VON HAUER.

[Proceedings Imp. Acad. Vienna, March 1857.]

A SERIES of fossils collected by M. Melling from the Raibl-strata*, and presented to the Imp. Geol. Institute, has been examined by Fr. von Hauer, who determines fifteen species of fossils from these beds. Five of these species, occurring also in the St.-Cassian-beds, prove the Raibl-beds to belong to the Upper Triassic series. The fossil fauna of Raibl, however, bears a peculiar and distinct *facies*, characterized by the nearly complete absence of Brachiopods and Cephalopods, by the scarce and dispersed occurrence of Gasteropods, and by the predominance of Bivalves, especially of forms hitherto exclusively met with in the upper portion of the Alpine Trias.

[COUNT M.]

* See also page 20. This particular series of deposits was first noticed by Boué, and afterwards described by von Hauer, Foetterle, Peters, and Stur, in other localities of Carinthia, in Carniolia, in the Venetian Alps, and in the Alps of Lombardy, where they had generally been confounded with the Muschelkalk.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On Plant-remains *in some of the* Austro-Hungarian Strata. By Prof. Unger.

[Proceedings Imp. Acad. Sciences, Vienna, December 11, 1856.]

1. The Vegetable remains in the freshwater limestone and quartz of Styria (Rein, Strassgang, and Thal), of Illinik (Hungary), and Tuchorzic (Bohemia), together with those occurring in similar deposits near Bonn and Mayence, and in Central France, &c., prove the littoral vegetation around the small lakes of the Tertiary period to have been but scanty, although the terrestrial and freshwater Molluscous fauna was numerous and varied. The sediments above alluded to are remarkable for their close affinity with the calcareous and siliceous tuffs, the travertinos, &c. at present in course of formation in Tuscany and the Roman States.

2. In the Leitha-limestone the only vegetable remains are some species of silicified wood; none of them are peculiar to this deposit, all having been met with in other Tertiary strata. The condition and situation of these fossils appear to prove that in this limestone they have been imbedded in their original position.

The Leitha-limestone consists nearly throughout of concretionary ramiform calcareous masses, having a radiating form, and resembling some coral-structures and stalactitic accretions. Dr. Reuss ranked these branching bodies among the *Milleporinæ*, under the name of *Nullipora ramosissima*. Dr. Haidinger considers them to be merely inorganic concretions. Prof. Unger, however, endeavours to prove that both these views are erroneous, and that the concretions are of vegetable origin. Prof. Philippi, of Berlin, has clearly shown that several marine calcareous organisms, usually regarded as Zoophytes, are peculiar forms of *Algæ*, belonging to his genera *Lithophyllum* and *Lithothamnium*. Prof. Unger has observed these *Algæ* to have a still greater extent, to produce the most extraordinary forms of crusts and stalactitic masses, and to consist entirely of a stony matter so hard that it can only be broken by means of iron tools. The vegetable texture appears clearly when the calcareous particles are removed by the action of diluted acids; and presents a system of parallel articulated tubes, connected by lateral anastomoses. The carbonate of lime is secreted and deposited both in the intertubular gelatinous substance (involucral membrane), and in the interior of the elementary cells, together with an occasionally very large amount of starch, so that the whole texture passes into a solid substance. These *Algæ* are, therefore, in some measure, self-petrifying plants, the vital functions of which, as those of the Corals, remain visible only at the extremities.

The same structure has been ascertained by Prof. Unger to exist in the problematic concretions of the Leitha-limestone, which, in consequence, may be considered to be chiefly of vegetable origin. This limestone has been supposed to represent the remains of *reefs* in the Tertiary seas; and this supposition is confirmed by two characteristic forms in which this rock occurs. The first of these conditions (occurring in the Sausal Mountains of Styria) has the aspect of a real coral-reef, chiefly composed by stony structures of *Sarcinula gratissima*, mixed with some few species of *Astræa* and *Explanaria*. The second form, intimately connected with the former by transitional characters and by its mode of deposition, is the Nullipore-limestone, in the strict sense of the term; and, apparently formed on a muddy sea-bottom, it skirts the outlines of shoals.

Prof. Unger thinks that our knowledge of the reefs in the existing seas is still too imperfect to enable us to decide what share in their formation is due to the above-mentioned lithogenous *Algæ*.

The presence of genuine reef-forming Corals in the Pannonian basin of the Tertiary period (at 47°, and more, N. lat.), while at present the northern limit of such Corals in the Red Sea and Persian Gulf is 29° N. lat., may be regarded as a strong evidence of the connection of that basin with these gulfs in Tertiary times. It may be supposed that the warm water of the Indian Ocean, passing over the present Isthmus of Suez, overran the Pannonian Coral- and Algæ-reefs, affording them the necessary conditions for their development; just as the Gulf-stream at the present day acts on a similar marine vegetation along the western coast of Norway, which is there used for manufacturing lime, as the Leitha-limestone is in Austria. The Leitha-limestone, especially the Nullipore-rock, being of vegetable origin, at least in the proportion of five to one, has been extensively used in Vienna as building-stone for many centuries; this capital, therefore, may be said to be built of vegetable remains (*Nulliporæ*), as Paris is of the remains of minute animals (*Miliolites*).

[COUNT M.]

On the GLACIER *of* SULDEN (VEDRETTA DEL MONTE MARTELLO) *in* TYROL. By MAJOR DE SONKLAR.

[Proceed. Imp. Acad. Sciences, Vienna, December 11, 1856.]

MAJOR DE SONKLAR in the summer of 1856 visited this glacier, situated in the background of the Sulden Valley, bounding to the east and south the *massive* of the Ortles. The glacier is composed of three principal affluents, 17,154 feet (Austrian) long, and is spread over a surface of 98,000,000 square feet. It terminates, at the altitude of 7000 feet, at the Legerwand, where the valley sinks with a nearly perpendicular slope of 300 feet.

Since its last slight movement (in 1846), the glacier continued to retire. In the spring of 1856 it again became upheaved, swollen, and traversed by several fissures; until, in the middle of June, its heaped-up fragments began rushing down the Legerwand, and continued to fall so quickly that after a few weeks a regenerated glacier, of more than 600 feet in length, with "ribboned" structure and several small fissures, was formed at the foot of the precipice. After the glacier began to fall over the Legerwand, it advanced more than 6 feet daily, and this progress materially increased after the great cold of November 1856.

A former outbreak of the same glacier took place in 1817 and 1818, when it advanced 4200 feet (Austrian) within sixteen months, and thrust a mass of ice of more than 1,000,000,000 cubic feet down the Legerwand.

Major de Sonklar is of opinion that such energetic movements of a glacier are not to be exclusively ascribed to general meteorological causes; but that local circumstances, although still very imperfectly known, must have influence on these phenomena. This observer points out, that the existence of more than seventy glaciers on limestone-mountains is opposed to the assertion made by MM. Schlagintweit, that calcareous rocks are unfavourable to the formation of glaciers. [COUNT M.]

On the GEOLOGY *of the* EASTERN ALPS. By FR. VON HAUER.

[Proceed. Imp. Acad. Sciences, Vienna, January 1857.]

IN exhibiting and explaining his section* of the Eastern Alps, from Passau on the Danube to Duino on the Adriatic, Chev. Fr. von Hauer noticed that among the most important facts elucidated by this section are,—1st, that the triassic and liassic deposits are nearly identical on the north and south slopes of the Eastern Alps; 2ndly, that the strata of more ancient date, on the two sides of these Alps, differ considerably from each other; and may be regarded as having been formed at different epochs, owing to violent movements in this region, coincident with the palæozoic period; 3rdly, that the more recent deposits of the north slope are not in accordance with those on the southern slope, and must have been formed under the influence of very different conditions; 4thly, that the last upheaval during the Tertiary epoch took place at a very different time on the two sides of the Eastern Alps. [COUNT M.]

* The scale of the original survey (prepared for the Imperial Geological Institute) is $\frac{1}{288{\cdot}000}$ nat. size; it is to be published on the same scale as that of the Staff Corps special maps ($\frac{1}{144{\cdot}000}$ nat. size).

On the Inundation *in the* Vintschgau *in* Tyrol. By Prof. Simony.

[Proceed. Imp. Acad. Sciences, Vienna, January 1857.]

In giving an account of the effects of the torrential inundation which took place, in June 1855, in the Vintschgau (Tyrol), Prof. Simony remarked that the Rezchenscheideck (altitude 4850 feet) is only 100 feet above the highest point of the Upper Adige Valley, which has an inclination of only 107 feet in $\frac{4}{5}$ths of an Austrian mile (about 4 English miles). The Adige, when leaving the Lake of Haid (altitude 4556 feet), the lowest of the three water-basins of this valley, has already acquired rather considerable dimensions. Its inclination from its point of issue to Glurns, in $\frac{4}{5}$ths of an Austrian mile, is $\frac{1}{15}$th of its length. From Glurns downwards to Spondinig (altitude 2824 feet), the valley enlarges and becomes nearly horizontal, the slope being not above $\frac{1}{514}$th, and increasing only to $\frac{1}{290}$th between Spondinig and Laas. Between Laas and Schlanders (altitude of the Adige bridge being 2270 feet) a cone of detritus, $\frac{3}{4}$ths of an Austrian mile in length, crosses the valley, and the Adige runs down this natural barrier with a slope of $\frac{1}{46}$th.

The inundation was a necessary consequence of continuous rain-falls and extensive melting of snow. Its destructive effects were increased by the breaking-out of the Lake Haid ; in consequence of which three villages next to the steepest course of the Adige were almost entirely destroyed, and Glurns threatened with a similar calamity. The effect of the raging torrent between Lake Haid and Laatsch was merely erosive. Its bed, of an average breadth of from 60 to 90 feet in its normal condition, was extended in some localities from 180 to 540 feet. The volume of detritus torn out along this extent, and afterwards in great part deposited on the plain of Glurns, may be estimated, at a very moderate computation, to be between 5,400,000 and 6,480,000 cubic feet.

The debris deposited near Schleiss by the Schlinig rivulet, in such quantities that it covered several houses to the top of the roofs, is of geological interest, its outlines and the disposition of the fragments contained in it offering a striking analogy with some phænomena observed in ancient diluvial deposits. [Count M.]

On the Distribution *of* Plants *on the* Styrian Alps. By M. Stur.

[Proceed. Imp. Acad. Sciences, Vienna, March 12, 1857.]

M. Stur communicated a paper on the distribution of plants on soils of different natures, as observed by him during his excursions in parts of Carniola, the territory of Goritzia, and part of the Illyrian sea-board, during the summer of 1856. He stated that he considered the chemical constitution of the soil should not be the only one of its physical conditions to claim attention in vegetable geography, as is often the case. Soils identical in physical conditions bear identical species of plants, notwithstanding wide distances separating them; as proved by the floras of the Alps and of Lapland. MM. Hegetschweiter and Heer have brought forward proofs of the vegetable types being capable of undergoing more or less imitations within certain limits, and these changes being caused by external agents, either of climatological or of geological and chemical nature. The only effect of climate is to stop or to favour the developmental growth of individuals. The alterations of form must therefore be ascribed to the nature of the soils, especially as these forms remain constant on soils of identical constitution.

M. Stur has come to the following results:—1st, calcareous prevailing over siliceous rocks in the regions explored by him, meadows are of scarce occurrence within it; nor is it in general favourable to the development of agriculture, owing to a greater proportion of rocky soil than of loose soils of mixed condition; 2nd, cereals are only cultivatable in mixed soil; their extreme limit above the sea-level is nearly the same on the north and the south portions of the calcareous Alpine chain, and depends completely on the altitude reached by the loose soil indispensable for their cultivation; 3rd, the upper limit of compact forests within the region under notice is accessible only in the Wochein district: notwithstanding frequent irregularities, it may be stated in general terms that the upper limit of the forest, like that of the cereals, is considerably lower here than in the Central Alps. This may be connected with the smaller amount of upheaval affecting the lower portion of this region.

[Count M.]

On the Caverns *in* Mount Oetscher. By Dr. Schmidl.

[Proceed. Imp. Acad. Sciences, Vienna, April 1857.]

Dr. Schmidl was assisted in his investigations of the Oetscher Caverns (in the Alps between Lower Austria and Styria), in September 1855, by MM. Lucas, Pohl, and Schabus. The portion of these caves called the Taubenloch (Pigeons-hole), 294 feet in length, and 44 feet in breadth, offers no object of interest, except traces of fallings which have taken place since 1747, as inferred from a description of this cavern of that date. Another portion, called the Seelucken (Lake-hole, on account of a pond in it), and subsequently Geldloch (Money-hole, from Italian adventurers having been supposed to have found treasure in it), is one of the largest caverns known in the Austrian Empire. It measures 1080 feet in length, 156 feet in its greatest breadth, and 108 feet in its greatest height. It is still more remarkable on account of ice continually being formed in it on an unusually extensive scale. A pond in the interior, 150 feet from the mouth of the cavern, is 90 feet long and 6 to 12 feet broad, and has a depth of from 4 to 5 feet. This pond is frozen over during the hot season; it begins to thaw in the autumn, and at the end of September one may wade across its muddy bottom. A slope, rising from the further bank of the pond, with an average inclination of 62°, a height of 54 feet, and a breadth of 60 feet, is completely coated with hard ice a foot thick, and is surmounted by a pyramidal mass of ice, 24 feet high (reaching to the roof). Behind this natural wall is a second cave, 144 feet long, 60 feet broad, and 36 feet high, the bottom of which is covered by crusts and stalagmites of ice, and from its ceiling hang icy stalactites.

Both these caverns have their outer portions nearly corresponding in position with the magnetic meridian, and afterwards bifurcate into two branches, the western of which is the larger one, probably joining at some distance the other and less extensive eastern branch. The branches of each cavern terminate in high ascending chimneys or pits; the pit of the Taubenloch reaching upwards to the height of 96 feet.

The temperature of the ice-cave itself is 1°·7 R.; it falls to 1°·4 R. in the gallery behind it, out of which comes a strong current of air. This gallery is generally dry; ice occurs in some parts of it. A small pond of water at the end of the eastern lateral branch was found to have a temperature of 2°·5 R. [Count M.]

On the Metalliferous Deposits *in* Upper Carinthia. By M. Lipold.

[Proceed. Imp. Geol. Instit. Vienna, April 18, 1857.]

The following observations have reference to that portion of Upper Carinthia surveyed by M. Lipold in 1856. The well-known quick-silver-mines of Idria are being worked on a thick vein (Stockwerk), dipping N.E., and belonging (as repeated chemical analyses seem to prove) to the Gailthal or the Alpine Carboniferous strata. These mercuriferous rocks contain more or less silica and alumina, combined with a considerable proportion of carbonate of magnesia. Mercury occurs likewise near St. Oswald, and near St. Thomas (Laak) on the boundary between the Werfen- and the Gailthal-strata; and it has been also recently found in the deeper portions of the Knaponsche lead-veins.

Outcrops of copper-ores are frequent in Upper Carniolia, especially west of Laak, towards Kirchheim in Goritzia. The ore worked by M. Kanitz, with much perseverance and a good prospect of success, is generally massive and variegated sulphuret of copper, with from 40 to 50 per cent. of metal, in lenticular or thick layers, on the limit between the Werfen- and Gailthal-strata; yellow sulphuret and grey copper-ore only occasionally occurring. A cupriferous deposit, here and there of several fathoms'* thickness, has been opened to an extent of 240 feet, and to the same depth. Other layers, in the same geological position, contain only yellow copper-pyrites, and are still but little worked.

Lead occurs, in the form of galena, in a vein of quartz and quartz-

* An Austrian "klafter" is somewhat more than an English fathom.

conglomerate, running north and south, and dipping east at a steep angle. It is worked at Knaponsche, with a monthly produce of 300 lbs. of lead. Lenticular deposits of lead-ores occur also in the Gailthal-strata of Kraken, Kirchstädten, and elsewhere.

Zinc, in the form of sulphuret, is only known at Kamnitza, Zirkousche, and other localities, where it is found interspersed with copper-pyrites and galena.

Iron-ores (pisiform-ores and ochreous brown hydrate of iron), mixed with loam and detritus, are frequently met with filling up small fissures and basins at the surface in the triassic, jurassic, and cretaceous limestones. The exploitation of these ores is somewhat costly on account of their inconsiderable depth and scattered position. Similar ores being found regularly imbedded in the nummulitic depo its of the Feistritz Valley, M. Lipold considers the pisiform iron of the calcareous Alps to be generally of eocene origin.

Ochreous and sandy brown hydrate of iron, of quite a different character, is imbedded in the Werfen-strata of St. Urban and in the Gailthal-strata of Hottaule. Oolitic ironstone and brown hydrate seem to form a continuous bed on the northern slopes of the Schintza Valley, near Podliva; they are now regularly worked.

Gypsum occurs in the mercuriferous rock at Laak. Anthracite is found near Idria, and in other localities, in narrow veins, or more generally in granules mixed with matrix of the metalliferous bed, or with the ores themselves. [Count M.]

On some Lignites *in* Southern Styria. By M. Fœtterle.

[Proceed. Imp. Geol. Instit. Vienna, April 18, 1857.]

The lignite-deposits near Wies and Schwanberg, west of Leibnitz, in Southern Styria, form the lowest member of a group of tertiary freshwater marl-shales, plastic clay, and gravel, in the basin between the eastern extremity of the Ror-Alpe and the Sausal, and communicating with the marine basin of the Mur Valley. The same lignite occurs almost invariably in the isolated tertiary deposits of Eibiswald, Wies, Steieregg, and Schwanberg, which have been subject to upheaval, and are cut through by the mountain-torrents.

The thickness of the lignite-beds varies from 3 to 10 feet; and, in a single instance (Steieregg), it amounts even to 15 feet. Their direction is very variable; their dip varies from 8° to 16°. Between Schönegg and Tombach, a bed, 3 or 4 feet thick, lies nearly in the centre of the hill, cropping out on both sides. The Steieregg lignitiferous deposit affects the form of a basin, in which the fossil fuel, 8 to 16 feet thick, is opened out to the extent of more than 10,800 feet (something above 2 English miles).

According to an average calculation, the quantity of fossil fuel at present opened may amount to from 150,000,000 to 200,000,000 cwt. This fuel is an "old brown-coal," of good quality, containing from 9 to 14 per cent. of water, and leaving 5 to 12 per cent. of ash; from 10 to 13 cwt. is the thermogenic equivalent of a fathom.

[Count M.]

On some of the Iron-ores *of* Styria. By M. F. von Hauer.

[Proceed. Imp. Geol. Instit. Vienna, May 1857.]

With regard to the iron-mines in the Tragöss Valley, near Bruck, in Styria, M. von Hauer observes that crystalline rocks appear in the lower portion of this valley, the upper part of which is formed of grauwacke, overlaid by grauwacke-slates and limestones, separated by a zone of Werfen-slates and conglomerates from the still higher calcareous masses, of more recent origin. The iron-mines are in the highest portion of the grauwacke-rocks, the same which, at a distance of from 18,000 to 24,000 feet to the west, contain the inexhaustible stores of carbonate of iron, which are worked in the Erzberg near Eisenerz. A rich bed of ironstone, increasing in value and thickness with the depth, has been opened by the Kegelang mine, and is imbedded in and alternates with grauwacke-slate. Its total thickness is 12 feet; and its extent, as indicated by outcrops, is more than 600 feet. The carbonate of iron is associated with white ankerite and quartz. The best sort of ore gives above 40 per cent., and, after roasting, above 60 per cent. of iron.

A group of ferriferous beds lately discovered to the south of the Zober-Kogel, between grauwacke-limestone and variegated sandstone with their conglomerates, is of still greater importance. The total thickness of this group is above 200 feet. The ores are very calcareous; those gathered at the surface give nearly 20 per cent. of iron; a solid mass of ore gave 36·4 (after previous roasting, 51·9) per cent. The ore may therefore be expected to become more productive at a greater depth, and to be advantageously mixed with the softer and quartziferous ores of Kegelang in smelting.

[Count M.]

On the Black Coal *of* Cosina. By M. Fœtterle.

[Proceed. Imp. Geol. Instit. Vienna, May 1857.]

Black-coal occurs at Cosina, two and a half Austrian (about twelve English) miles south-east of Trieste, and at Vrem and Skoffle, near that city. In the first of these cases, the deposit is a lenticular mass, its greatest diameter being from 30 to 36 feet, and its thickness not more than 2½ feet. Another mass, of scarcely greater importance, has been opened at a distance of about 600 feet from the first. Both are imbedded in the lowest part of a black bituminous limestone, containing Upper Chalk fossils, and very similar to the well-known ichthyolitic calcareous slates of Corea. This limestone rests on Hippurite-limestone, and is overlaid by Nummulitic limestone, on which reposes an eocene sandstone, commonly called "Macigno" or "Tassello."

The geological position of the coal at Verm and Skoffle is identical with that of Cosina, but it occurs in such scattered and limited deposits that it is not worth working. [Count M.]

On the GEOLOGY *of* BUDA *and its* ENVIRONS. By Prof. PETERS.

[Proceed. Imp. Geol. Instit. Vienna, May 1857.]

PROF. PETERS' observations especially refer to the banks of the Danube between Hanzelbek and St. Eudree. The oldest rock of this district is a white, compact, frequently dolomitic, and occasionally red-veined limestone, forming an extensive and hilly area, covered with forests, between Kooacri and the Valley of Buda-Keszyi. As no fossils have yet been found in this limestone, it is difficult to determine its geological age, and to distinguish it from the younger eocene limestones and dolomites. The eocene deposit following next is an extensive Nummulitic limestone, frequently dolomitized, of 200–250 feet thickness, and comprising nearly the whole of the Buda dolomites, especially the white friable varieties, used for scouring-purposes. Next in age comes a yellow and grey, eocene, calcareous marl, with subordinate beds of sandy and loamy marls, and of Nummulitic limestone; total thickness, 450 feet. This marl constitutes the Fortress Mountain, the north-west portion of the Blocksberg, the eastern part of the Schwabenberg, and generally most of the hills around Buda.

The eocene plastic clays (Tegel), highly developed around Gran, are strictly separated from both the above-mentioned series of deposits. A small portion of the clays, compressed by the Nummulitic limestone of Mount Calvary, and overlaid by freshwater deposits, extends as far as the environs of Buda.

The Neogene deposits of Buda may be subdivided thus:—1. Lower and middle plastic clays (corresponding to the Tegel of Baden, near Vienna). 2. Yellow sands, analogous to those of Vienna Leitha-limestone. 3. Leitha-limestone. 4. Cerithian limestone, intimately connected with the Leitha-limestone. 5. Sands and sandstones, with remains of *Aceratherium incisivum*. 6. Lignitiferous freshwater deposits. 7. Trachytic tuffs. The older Diluvium seems to be wanting; the later Diluvium is represented by extensive deposits of Loess and by calcareous tuffs. [COUNT M.]

On the GEOLOGY *of Part of the* TYROL. By MM. FŒTTERLE and H. WOLF.

[Proceed. Imp. Geol. Instit. Vienna, June and July 1857.]

IN the southern extremity of the Tyrol, as far down as Roncono, Trente, and Val Sugana, the lowest rocks seen are Verrucano and dark-red sandstone, forming a mountain-mass towards the Chieza, between Lodrone and Cologna, down to the frontier of Lombardy. They are overlaid by Lower Muschelkalk, Dachstein-limestone, and dolomites, without the intercalation of Upper Triassic strata. Dachstein-dolomite, with imbedded Kössen-strata in Val Ampola, extends between Val Bona and the Lake of Garda, and on the foot of the steep rocks along the Sarca and Adige valleys from the Venetian Frontier upwards to Trente, where it occupies the lowest place in the strata, which have been much upheaved in conformity with parallel fissures.

In the centre of the region in question, the Dachstein-limestone is overlaid by limestones having oolitic structure, and of greyish-yellow or white colour. In the lower part of these limestones are beds of marl, which, when softened by inordinate quantities of water, are the causes of great earth-slips. The enormous blocks choking the Adige Valley at Marco, south of Roveredo, have been thus brought down the western slope of Monte Zenoa.

The rocks resting on the oolitic limestones are, first, red and grey Ammonitic Jurassic limestone, then Biancone and Scaglia. The same deposits appear regularly on the west banks of the Lake of Garda; but rest there on spotted marls or immediately on the Dachstein-limestone.

Eocene deposits are conspicuous near Torbole and Arco. Diluvial gravel occurs in considerable quantities near Arco, Tenno, and Villa.

Among the eruptive rocks, the syenites along the Sarca and Chiesa, and the porphyries along the Adige, are particularly noticeable. Melaphyres and basaltic rocks, although occurring in many localities of the Adige Valley, have nowhere conspicuously acted on the adjacent deposits.

The extended survey in Southern Tyrol, over the whole of the region of the River Sarca (Roveredo, Trente, Val Sugana, Primiero, and Giudicaria), showed that Werfen-slates, resting on mica-schist or on porphyries, and containing veins of carbonate of iron near Primiero, prevail over a great area. These slates have undergone considerable upheavals near Villarzano and Ravina, south of the Adige. The western range of the Werfen-slates, from Rancon to Dimaro, is nearly always gypsiferous, and is overlaid by rather thin strata of Guttenstein-limestones. Hallstadt-limestone and dolomite are confined to the region between Roncon, Tione, and Dimaro; the upper shell-limestone of the St.-Cassian-strata to the Giudicaria. The ferruginous oolites of Vigolo and Roncogno, west of Pergine, may probably belong also to the St.-Cassian-group. The Dachstein-dolomite occupies also an extensive area. The oolitic rocks resting on it are powerfully developed between Primiero and Val Sugana, also between the Sarca, the Adige, and the Lake of Molveno; they are full of characteristic fossils near Cadina (Tridentine) and Rozzo (Setté Communi).

Another far-spread rock is the red and light-grey Ammonite-limestone of the Upper Jura. It is overlaid by the nearly white Neocomian limestone (Biancone); and this by Cretaceous marl-slates, of an intense red colour (Scaglia).

The Eocene period is represented by Nummulitic limestones; the younger Miocene by shelly marls and insignificant lignite-beds. Diluvial gravel is extensively deposited in the Giudicaria. Abundance of good peat occurs over marly slates near Fiavè, south of Stenico.

[Count M.]

On the Trachytes *near* Pesth, Hungary. By Prof. Peters.

[Proceed. Imp. Geol. Instit. Vienna, June 1857.]

After a careful examination of the trachytic area between St. Andrae and Vissegrad, near Pesth, Prof. Peters has succeeded in determining the age of this trachyte. The trachytic mass is surrounded by a great Neogene deposit, consisting of the Lower Plastic Clay, sand, and Leitha-limestone, like those around Buda. In the vicinity of the trachyte the Leitha-limestone has generally given place to trachytic tuff, with a large proportion of organic remains in a calcareous state. The lower sands and clays (corresponding to the sand and Tegel of the Leitha-limestone of the Vienna Basin) present no vestige of any trachytic substance. Hence it may be inferred that eruption of the trachytes was coeval with the formation of the Leitha-limestone proper.

The Diluvial deposits have likewise evidently been modified by trachytic influence. The Loess is mixed with trachytic gravel: a deposit of tuff, with Diluvial fossils, near St. Andrae, is full of concretions and small veins of brown opal and siliceous minerals.

An unsuccessful search for fossil fuel in the middle neogene clay of Megyer has led to the discovery of abundance of *Cerithium margaritaceum*, a form nearly allied to *C. calcaratum* and *C. striatum*, both occurring in the eocene clay of the lignitiferous district around Gran. [Count M.]

On the Cervus euryceros. By Prof. De Morlot.

[Proceed. Imp. Geol. Instit. Vienna, June 1857.]

M. de Morlot thus announces the discovery, by MM. Uhlmann and Jahn, of remains of the gigantic Elk (*Cervus euryceros*=*Megaceros hibernicus*) in association with works of human industry. On partially draining, in 1856, a small lake near Moosseedorf (Canton of Berne), an area of about 70 feet in length and 50 feet broad along the bank of the lower extremity of this lake was found to be paved more or less closely with posts of oak, aspen, birch, and elm, driven through two beds of peat into the marly bottom of the lake. A peat-bed, 3 or 4 feet thick, of exclusively vegetable origin in its upper part, includes many relics of human industry and art in its lower portion. Dr. Uhlmann collected nearly a thousand specimens; viz. fragments of pottery, stone-chisels, stone-arrowheads, pieces of cut bones, and perforated bear-teeth, without any traces of metallic objects. The lower ends of the posts have evidently been also worked into their pointed shape by the means of stone-tools. The upper portion of the bed containing these remains exhibited traces of combustion and contained carbonized grains of barley.

Together with the above-mentioned works of art were found many fragments of the bones both of domesticated and of wild animals; viz. horned cattle, horses, swine, dogs of various size, goats, sheep, cats, elks, stags, aurochs, bears, wild boars, foxes, beavers, tortoises, several birds, and other animals still undetermined. An atlas and jaw, however, sent by M. Trogon to Prof. Pictet, of Geneva, were ascertained by this eminent palæontologist to belong to *Cervus euryceros**. The length of the atlas is 0·265 metre, and its breadth 0·088 metre; both differing only by $\frac{1}{1000}$ from the measurements stated by Cuvier. [Count M.]

On the occurrence of Thallophytes *in the* Cretaceous Strata *of* Aix-la-Chapelle *and* Maestricht. By Dr. Debey.

[Proceed. Imp. Acad. Sciences, Vienna, July 16, 1857.]

As far as our present information extends, the *Algæ*, the lowest form of vegetables, occur in primæval marine deposits in a proportion far inferior to that which may be inferred from the predominance of sea over land in those remote ages. Fossil *Algæ* are generally small and of very delicate structure. Gigantic forms, such as the living *Lessonia fuscescens*, *Macrocystis pyrifera*, and others, measuring from 700 to 800 feet in length, and equalling a man's arm in thickness, seem to have been wanting in the extinct marine floras. Moreover, many fossil plants originally ranked among the *Algæ*, have been proved recently not to belong to this class, or, at least, to be of a dubious character. The forms that have been named *Confervites*, *Caulerpites*, *Chondrites*, *Cylindrites*, *Keckia*, *Encoelites*, *Muensteria*†, &c. are still very doubtful, and indeed may never have belonged to any organized being. Other forms, belonging to quite different subdivisions of vegetables far higher in the organic scale, have been erroneously ranked among the *Algæ*, as, for instance, several species of *Caulerpites*, recently raised to the rank of Coniferæ.

By the investigation of the Cretaceous flora of Aix-la-Chapelle, although it be richer than all other coëval floras taken together, the proportion of the *Algæ* to the other vegetable forms of the Cretaceous period is lowered to $9\frac{1}{10}$ *per cent.* The class of *Lichenes* is represented in the Aix-la-Chapelle strata by only one form, answering to the genus *Opegrapha*. Some forms undoubtedly belonging to the *Fungi*—a class never before ascertained to have existed during the Chalk-period—have been lately met with. Since Prof. Goeppert's striking discovery of a foliar *Fungus* (*Exstipulites Neesi*) on the fronds of a Fern from the Carboniferous strata, there is nothing surprising in the occurrence of similar forms in more recent deposits. Five species of *Xylomites* have been found in the Lias; at least forty species of different genera have been observed in Tertiaries, and especially in amber. They are generally foliar *Fungi*, occurring on Insects or on fossil wood. Distinct remains of two species of *Fungi* analogous to the existing genera *Œcidium* and *Himantia* have been found on the foliar impressions of *Dryophyllum*, a fossil genus of *Proteaceæ*. A third species, similar to a *Sphærium*, was met with

* See Bibliothèque Universelle, Mai 1857.

† Also *Scolithus*: Quart. Journ. Geol. Soc. vol. xiii. p. 204.—Edit.

on the remains of a monocotyledonous leaf: a fourth, reminding one of a *Hysterium*, on a dicotyledonous leaf.

Dr. Debey intends to publish similar papers on the other classes represented in the Cretaceous flora*,—one of the still least known of all fossil floras, although in number of species it is only inferior to those of the Carboniferous, Eocene, and Miocene periods. New and peculiar forms filling up systematic hiatuses have been discovered in the Cretaceous strata; and genera still living may be traced even to this early epoch. A narrow connection between the Cretaceous and the immediately subsequent period has been indicated by the occurrence in the Aix-la-Chapelle strata of characteristic Australian plants,—a type which obtains pre-eminence during the Eocene period.

[Count M.]

On the Geology *of some Parts of* Bohemia. By MM. Stur and Jokély.

[Proceed. Imp. Geol. Instit. Vienna, July 1857.]

M. Stur finds that in the environs of Tabor and Sedletz, in North-western Bohemia, the prevailing rock is gneiss, of many varieties, dipping beneath clay-slates, and (near Tabor) beneath granite, and leaning against granite near Nachod. Micaceous strata alternate more or less regularly with others containing but little of this mineral, and dipping, at a low angle, northward in one part, and north-westward in the other part of the district. Near Horky the gneiss includes two argentiferous veins, which were worked at intervals from the 13th to the 19th century, but are now abandoned. The ores, extracted from a depth of 480 feet, contained 36 *per cent.* of lead and 1½ *per cent.* of silver.

An amphitheatre of granitic hills surrounds the south and south-western continuation of the gneiss between Nechwatitz, Neuhof, Sedletz, Neukostcletz, and Borotin. This granite is white and fine-grained. In the north-western portion primary clay-slate is seen dipping beneath gneiss with medium-sized grains; this last dipping beneath porphyroid granite and granitic gneiss.

Amid the gneissic region lies the granitic *massif* of Tabor, to which the attention of geologists was first drawn by M. Zippe. This granite, passing from fine-grained to compact, is bluish-grey when fresh, and becomes brown by weathering. It is characterized by large thin laminæ of mica, imparting to it a porphyroid aspect. Between this granite and the porphyroid granite of Gistiebnitz is intercalated a series of gneissic bands, with subordinate calcareous and amphibolic beds.

M. Jokély found that, in the environs of Auscha and Sandau, eastward of the Elbe and Leitmeritz, in North-western Bohemia, the prevalent rocks are Cretaceous and eruptive. The three subdivisions

* See Quart. Journ. Geol. Soc. vol. vii. part 2, Miscell. p. 111.

of the Cretaceous formation :—Lower Quader sandstone,—the Pläner, with its characteristic species of *Inoceramus, Exogyra, Ostræa,* &c. (not above 48 feet thick),—and the Upper Quader, in steep cliffs more than 100 feet high, are all well developed. This system is terminated to the north somewhat abruptly by a valley-like depression, probably connected with the basaltic eruption, and running through Graber, Auscha, and Libeschitz, and along the Egra Valley. Northward of this depression, the Cretaceous beds, depressed under basaltic tuffs of various kinds, are only visible in the deeper parts of the valleys.

These tuffs are more or less of an arenaceous or argillaceous composition, and alternate with genuine basaltic tuffs, basaltic conglomerates, and solid basalt. Here and there they contain beds of brown-coal, nowhere more than 3 feet thick. The argillaceous tuff-beds include numerous remains of land-plants and freshwater molluscs. One of them, resembling bituminous slate, is full of remains of Batrachians. These strata are more recent than the sandy ones of Saatz, but older than the upper lignitiferous beds of the Saatz, Falkenau, Ellbogen, and Egra basins*.

The brown-coal strata are frequently disturbed by masses and veins of basalt. Phonolite appears in several localities amidst basalt, traversing it in large veins, without, however, having caused any notable disturbance. Trachyte is spread over isolated areas. It appears as a completely closed crater of elevation, of about 200 feet diameter, on the Ratzk Mountain, near Lewis. A similar crater, closed northward by a wall of phonolitic slag, occurs near Algersdorf.

The basalt appears to have been erupted in several large currents or beds, continuing without interruption for several miles. In the central region they are disposed in horizontal or slightly inclined layers, alternating with tuffs and conglomerates of the same origin. Nearer to the circumference, their remains appear in the form of isolated hills or flat ridges. This basalt is generally porphyroid, containing olivine ; occasionally it is amygdaloidal, porose, or scoriform. The older basaltic strata are frequently cut through by veins or funnel-shaped masses of more recent basalt. The same variety appears, in the shape of hills, with columnar structure ; while the more ancient affects a tabular or spheroidal structure. The beds of tuff and stratified basalt contiguous to the younger eruptive basalt are generally inclined inwards in the hills.

Tenacious Diluvial loam occurs even on the higher zones of the valley-slopes. Diluvial gravel is scarce.

The highest central portion of these mountains, around Warnstadt and Tribsch, is impressed with a still more decided volcanic type. The only visible sedimentary rock is sandstone with brown-coal, cropping out in deep valleys or in the vicinity of phonolites and basalts which have upheaved it. Trachyte is seen in many places cutting through basalt and phonolite ; and here and there it rises into hills of striking outlines, or breaks, without intermediate tuffs and

* See above, p. 11.

conglomerates, through strata of Tertiary sandstone. Trachytic conglomerates occur around Micheln. A continuous range of basalt (called the Fourteen Mountains) runs between the Zinkenstein and the Planberg. In its deeper parts, alternations of old basaltic strata with various Tertiary beds may be observed, as also the youngest basalts traversing even trachytes younger than the first basalts. Porphyritic dolerite is met with exclusively on the Letschin Mountain.

The brown-coals of this district are far from being considerable; four of the beds near Selesel are of superior quality on account of their having been converted into anthracite and native coke by the agency of the basaltic and trachytic eruptions.

[COUNT M.]

On the GEOLOGY *of the Neighbourhood of* INNSPRUCK. By M. VON HAUER.

[Proceed. Imp. Geol. Instit. Vienna, July 1857.]

THE most ancient rocks in the Valley of the Inn, near Innspruck (in the exploration of which M. von Hauer was assisted by M. Fœtterle, Baron Richthofen, and M. Gumbel), are Werfen-slates, cropping out in isolated localities on the west banks of the Inn from beneath the Guttenstein-limestones, which form a continuous zone on the southern slope of the main range north of Innspruck. These are immediately overlaid by the light-coloured limestones, of the main range (Martinswand, Solstein, Wanger, Levatscher Spitz, &c.), designated as "Upper Alpine Limestone*" on the map published by the Tyrol Geological Society, but subsequently proved to be Hallstadt-limestones by their containing *Halobia Lommeli*, *Chemnitzia Rosthorni*, &c. These limestones are overlaid by a marl with the characteristic fossils of the St.-Cassian- and Raibl-strata, and running from Zirl to the Lavatsch Valley, then turning abruptly and continuing through the Hinterau Valley as far as Scharnitz. Above these marls lie extensive masses of dolomite ("Lower Dolomite" of the above-mentioned map), developed into a group of mountains near Seefeld, and which, being immediately covered by Koessen-strata, are considered by M. von Hauer to be of Lower Lias age.

In the Valley of the Lech, near Warth, Zurs, and Stög (where M. Escher also assisted in the explorations), marly and slaty beds containing Raibl-fossils (*Perna Bouei*, Hauer, and *Corbis Mellingi*, Hauer), and associated with much altered and disturbed dolomites, Dachstein-limestones, Koessen-strata, and white and red Adneth-limestones, again make their appearance. [COUNT M.]

* See also Quart. Journ. Geol. Soc. vol. x. p. 346.

The Fossil Mollusca *of the* Tertiary Basin *of* Vienna. By Dr. Moritz Hörnes. Vol. i. Univalves. 4°, 1856, Vienna. With 52 Lithographic plates.

[Die Fossilen Mollusken des Tertiär-Beckens von Wien, u. s. w.]

This magnificent Monograph of the Gasteropoda of the Austro-Hungarian Tertiary formations, by Dr. Hörnes, assisted by the late M. P. Partsch, was issued in Numbers, the first of which appeared in 1851, and the tenth in 1856. On its completion, the monograph has been published as a volume (the third) of the 'Transactions of the Imperial Geological Institute of Vienna,' with a short prefatory note from the pen of Dr. Haidinger, who feelingly alludes to the interest taken in the Vienna fossils by M. Partsch, and notices the co-operative labours of the artists and others in the work.

Five hundred species (90 genera) of Univalves * are described in detail and carefully figured in this work. The distribution of these fossils in the Vienna Basin, and their occurrence in numerous other localities are synoptically tabulated, pp. 687–711; their range in the several members of the Austrian Tertiaries being distinctly indicated.

This work is rich in synonymy and in detailed reviews of the labours of other conchologists; and a full register is given of the various works which the author has used during his laborious investigations. A map of the Vienna Basin, with geological indications of the principal localities from which the specimens figured were obtained, accompanies the memoir. Five subdivisions of the Vienna Tertiaries are given by the author; the following is the stratigraphical sequence in descending order:—1. Upper clay or "Tegel"; a brackish-water deposit. 2. Cerithium-bed; an important member of the series, constituting towards the centre of the basin a passage-group between the marine and the brackish beds. 3. Sand-beds, of considerable local thickness. 4. Clay-beds and sand of the Leitha-limestone; littoral deposits. 5. Lower "Tegel" or plastic clay; a purely marine deposit; often sandy.

The tabular conspectus previously alluded to gives a view of the occurrence and relative frequency of all the species described from the most important localities of the Vienna Basin and the rest of Europe, together with an indication of the forms still existing in the British, Mediterranean, and Tropical seas. Of the 500 species of Univalves described, $\frac{1}{5}$th still live in the Mediterranean; about $\frac{1}{25}$th (19) exist in the British, and nearly $\frac{1}{16}$th (31) in the Tropical seas; so that this Basin may be considered to present the first outlines of the present Mediterranean fauna, modified somewhat by a more tropical temperature.

The typographical and lithographical characters of the work are in every respect creditable to the Imperial press from which it has issued. [T. R. J.]

* Including one Pteropod,—and two, if *Dentalium gadus*, Mont., be also referred to this family.—Edit.