THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant —*Novum Organum, Præfatio.*

VOLUME THE TWENTY-FIFTH.

1869.

PART THE FIRST.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMANS, GREEN, READER, AND DYER.

PARIS: FRIED. KLINCKSIECK, 11 RUE DE LILLE; F. SAVY, 24 RUE HAUTEFEUILLE.

LEIPZIG: T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLXIX.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February 19, 1869.

President.

Professor T. H. Huxley, LL.D., F.R.S.

Vice-Presidents.

Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
Sir R. I. Murchison, Bart., K.C.B., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Rev. T. Wiltshire, M.A., F.L.S.

Secretaries.

P. Martin Duncan, M.B. Lond., F.R.S.
John Evans, Esq., F.R.S., F.S.A.

Foreign Secretary.

Prof. D. T. Ansted, M.A., F.R.S.

Treasurer.

J. Gwyn Jeffreys, Esq., F.R.S.

COUNCIL.

Prof. D. T. Ansted, M.A., F.R.S.
W. Boyd Dawkins, Esq., M.A., F.R.S.
P. Martin Duncan, M.B. Lond., F.R.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
John Evans, Esq., F.R.S., F.S.A.
J. Wickham Flower, Esq.
David Forbes, Esq., F.R.S.
R. A. C. Godwin-Austen, F.R.S.
Harvey B. Holl, M.D.
Prof. T. H. Huxley, LL.D., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S. & L.S.
Prof. T. Rupert Jones.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
John Carrick Moore, Esq., M.A., F.R.S.
Prof. John Morris.
Sir R. I. Murchison, Bart., K.C.B., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Earl of Selkirk, F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Alfred Tylor, Esq., F.L.S.
Rev. Thomas Wiltshire, M.A., F.L.S.
Searles V. Wood, jun., Esq.
Henry Woodward, Esq., F.Z.S.

Assistant-Secretary, Librarian, and Curator.

W. S. Dallas, Esq., F.L.S.

Clerk.

Mr. W. W. Leighton.

Library Assistant.

Mr. F. H. Waterhouse.

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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.]

VERTEBRATA (*continued*).

(*Reptilia.*)

EXPLANATION OF THE PLATES.

ERRATA ET CORRIGENDA.

Page xxxvi, line 21 from bottom, *far* Hereford *read* Sleaford.
 „ 18, line 25, for *gigantea* read *squamosa.*
 „ 21, line 18 from bottom, for *gigantea* read *squamosa.*
 „ 23, lines 12 and 20 from bottom, *for* Hussied *read* Husseid.
 „ 23, line 19 from bottom, *for* Bukel *read* Birket.
 „ 25, lines 8, 15, and 23, *for* Gamnal *read* Gammal.
 „ 31, line 12, *for* conchoidal *read* conoidal.
 „ 38, line 10 from bottom, *for* Fall *read* Bath.
 „ 41, line 16 from bottom, *for* cuneiform *read* cruciform.
 „ 44, line 12, *for* Accumulation *read* A circulation.
 „ 44, line 23, *for* Jerzoch *read* Jenzsch.
 „ 44, line 8 from bottom, *for* Nagh el Bader *read* Nagb el Bédra.
 „ 45, line 5, line 9 from bottom, and in note, *for* Nagh el Bader *read* Nagb el Bédra.
 „ 61, last line of description of figure, *for* pentagraph *read* pantograph.
 „ 62, line 4 from bottom, *for* 4 *read* 5.
 „ 63, line 11, *for* 3 *read* 5.
 „ 63, line 19 from bottom, *for* 5 *read* 4.
 „ 63, line 13 from bottom, *for* irver *read* river.
 „ 70, line 9 from bottom, and
 „ 71, line 19, *after* H *insert* Plate V.
 „ 76, line 9, *for* (C) *read* (E).
 „ 77, line 19, *after* gravel *add* and alluvium.
 „ 78, line 9, *after* B *insert* fig. 9.
 „ 79, line 1, *for* is *read* slopes.
 „ 86, line 4, after *d* add fig. 17.
 „ 86, line 12, *for* 19 *read* 17, and *for* VI. *read* VIII.
 „ 124, line 4, *dele* A.
 „ 128, line 6 from bottom, for *Robertsonii* read *Robertsoni.*
 „ 173, second footnote, *for* ii. *read* xi.
 „ 191, line 8 from bottom, *for* 280 feet *read* about 200 feet.
 „ 215, line 2 from bottom, *for* underlying *read* later than the.
 „ 252, footnote, last line but one, for *Calamopity* read *Calamopitys.*
 „ 383, line 4 from bottom, *dele* and.
 „ 400, first footnote, *for* Mason Wood *read* Wood Mason.
 „ 406, line 12, *for* rainfull *read* rainfall.
 „ 432, line 4, *after* Kent *insert* Surrey.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 19, 1869.

REPORT OF THE COUNCIL FOR 1868.

The Council of the Geological Society, in presenting their Report for the year 1868, have again to congratulate the Fellows on the prosperity of the Society, although the increase in the number of Fellows has not been so great as in some previous years.

The number of new Fellows elected was 46, of whom 36 paid their fees before the end of the year, making with 10 previously elected who paid their fees in 1868 an effective increase of 46 Fellows. Against this must be placed the loss of 18 by death, and of 5 by resignation, giving a net increase of 23 ordinary Fellows. The number of Contributing Fellows is now 487.

The death of 1 Foreign Member and of 4 Foreign Correspondents was announced in 1868. The latter have been replaced by 1 Foreign Correspondent elected during the year, and 3 elected since its close.

The total number of Fellows and Foreign Members and Correspondents of the Society at the end of 1867 was 1185; and at the end of 1868, 1204.

The Council have much gratification in reporting that the income of the year 1868 has exceeded the expenditure by £11 7*s.* 8*d.*, the total Receipts being £2037 16*s.* 4*d.*, and the total Expenditure £2026 8*s.* 8*d.* This result is especially a subject of congratulation, inasmuch as the greater part of the cost of a supplementary Number of the Journal for 1867, and the Law Expenses incurred by the Council in claiming exemption from parish rates, amounting in all to nearly £200, are included in the expenditure of 1868.

The Council have to announce the completion of Vol. XXIV. of the Quarterly Journal, and the publication of the first part of Vol. XXV.

The Council have also the pleasure of announcing that Mr. G. W. Ormerod having prepared a revised edition of his valuable Index to the various publications of the Society, in which the references are brought down to the end of last year, has presented the MS. to the Society. As nearly all the copies of the first edition of this Index have been sold, the Council did not hesitate about printing this new edition, a portion of which is already in type. The volume will be published as soon as possible.

The Council have to report that, in consequence of his appointment to the Secretaryship of the Royal Agricultural Society, Mr. Jenkins resigned his position as Assistant Secretary at the end of last year. After the consideration of the qualifications of several Candidates, the Council decided on electing Mr. W. S. Dallas to the vacant post. At the same time Mr. Skertchly also resigned his appointment as Assistant in the Library; and the Council have appoined Mr. F. H. Waterhouse as his successor.

The Committee appointed by the Council to discuss and report upon the duties of the Assistant Secretary, embodied in their Report certain recommendations with regard to the future management of the Museum, which would render it unnecessary any longer to employ an Officer entirely in the Museum. These recommendations having been adopted by the Council, Mr. W. S. Mitchell, the present Assistant in the Museum, will cease to hold that appointment after the 31st March next.

The Council have awarded the Wollaston Medal to Henry Clifton Sorby, Esq., F.R.S., F.G.S., in consideration of his patient and laborious investigations in the various departments of Physical Geology, and especially of his researches into the structure of Rocks, Minerals, and Meteorites.

The Balance of the proceeds of the Wollaston Fund has been awarded to William Carruthers, Esq., F.L.S., F.G.S., in aid of his valuable investigations in Fossil Botany, which have already led him to such important results.

Report of the Library and Museum Committee, 1868–69.

The Library.

The Standing Library-Committee have continued from time to time to make additions to the Library by the purchase of such books as they thought would prove useful to the Fellows; and amongst these the following works may be noted:—

Lecoq's 'Epoques Géologiques de l'Auvergne,' in 5 vols.; Alphonse Milne-Edwards's 'Recherches Anatomiques et Paléontologiques sur les Oiseaux fossiles de la France,' of which 22 parts are published; H. C. Weinkauff's 'Conchylien des Mittelmeeres, ihre geographische und geologische Verbreitung,' 2 vols; the continuation of L. Reeve's 'Conchologia Iconica;' H. Abich's 'Geologische Beobachtungen auf Reisen in der Gebirgsländern zwischen Kur und Araxes;' Professor Gervais's 'Recherches sur l'Ancienneté de l'Homme et la période Quaternaire;' Stoppani's 'Paléontologie Lombarde,' 4th series; and the third volume of the great French edition of the works of Aristotle in Greek and Latin, containing the portion of his writings relating to Natural History.

The Library has been increased during the past year by a great number of valuable donations, including, besides periodicals and the publications of Learned Societies, many separate works of importance, such as:—

Barrande's 'Système Silurien de la Bohême,' vol. ii., 'Céphalopodes Siluriens,' Text and Atlas; Greppin's 'Essai Géologique sur la Jura Suisse;' O. Heer's 'Fossilen Hymenopteren aus Œningen und Radoboj;' Eadmann's 'Exposé des Formations Quaternaires de la Suède;' F. J. Pictet's 'Matériaux pour la Paléontologie Suisse' (the commencement of a fourth series); Zigno's 'Flora fossilis Formationis Oolithicæ' (the completion of vol. i.); the second edition of Dawson's 'Acadian Geology;' the late Professor Hörnes's 'Fossilen Mollusken des Tertiärbeckens von Wien,' Bivalves 7 and 8; the conclusion of Gaudry's 'Animaux fossiles de l'Attique;' W. K. Parker's 'Monograph on the Structure and Development of the Shoulder-girdle;' Gümbel's 'Geognostiche Beschreibung und Karte des ostbayerischen Grenzgebirges,' with a magnificent Atlas; and the publications of the Geological Survey of the Grand Duchy of Baden, containing Maps and Descriptions of the Environs of Lahr and Offenburg, and of Möhringen and Mosskirchen.

A good many Maps and Plans have been added to the Society's Collection; they include the Maps of the Geological Surveys of the Netherlands (2 sheets), Sweden (4 sheets), Austria (2 maps), and Victoria (3 maps), those of the British Ordnance Survey, a Geological Map of the South-east of England presented by W. Whitaker, Esq., and a Geological Map of South Devonshire, prepared and presented by Dr. Holl.

Great inconvenience has often been experienced from the difficulty of arranging detached pamphlets, parts of serial works, and similar publications so as to render them easily accessible. A set of pigeon holes has now been made for the reception of such papers; and in these they may be kept in alphabetical order, and made more available for the use of the Fellows until they can be bound into volumes.

Mr. Skertchley resigned the office of Library Assistant at the end of the year 1868, and Mr. F. H. Waterhouse has been appointed his successor.

The Museum.

The following is the work that has been done in the Museum during the year 1868:—

1. Many specimens which were lying about in the Museum have been, as far as possible, restored to their proper places in the cabinets.

2. The whole of the British Collection has been examined and, as far as practicable, put into correct order; the drawers have been re-papered and the specimens and tablets cleaned, it being found that most of the labels were illegible through accumulated dust.

3. The Mammalian remains have all been treated with gelatine, and the broken bones and teeth put together, with the assistance of Mr. Boyd Dawkins and Mr. Davis (of the British Museum).

The Committee recommend that a sufficient supply of Tablets be provided for the South-African fossils and other specimens illustrative of papers read before the Society, and also that some covered deal Trays be made, to receive such specimens.

The Council having decided on the discontinuance of the formation of a general collection, and having restricted the collection in future to specimens illustrative of papers read before the Society and those received from abroad, recommend that the Assistant Librarian, under the superintendence of the Assistant Secretary, should take great care of the present collection, and should arrange all specimens as soon as received, with reference to the papers which they illustrate.

J. GWYN JEFFREYS.
P. M. DUNCAN.
THOS. WILTSHIRE.

Comparative Statement of the Number of the Society at the close of the years 1867 *and* 1868.

	Dec. 31, 1867.	Dec. 31, 1868.
Compounders	197	206
Contributing Fellows	469	487
Non-contributing Fellows	434	430
	1100	1123
Honorary Members	3	3
Foreign Members	42	41
Foreign Correspondents	40	37
	1185	1204

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c., at the close of the years 1867 *and* 1868.

Number of Compounders, Contributing and Non-contributing Fellows, December 31, 1867			1100
Add Fellows elected during former year and paid in 1868			10
Add Fellows elected and paid in 1868			36
			1146
Deduct Compounders deceased		5	
Contributing Fellows deceased		9	
Non-contributing Fellows deceased		4	
Contributing Fellows resigned		5	
			23
			1123
Number of Honorary Members, Foreign Members, and Foreign Correspondents, December 31, 1867		85	
Add Foreign Correspondent elected		1	
		86	
Deduct Foreign Member deceased	1		
Foreign Correspondents deceased	4		
		5	
			81
			1204

Deceased Fellows.

Compounders (5).

Sir G. Clerk, Bart.
N. Dennys, Esq.
Admiral Jones.
H. Porter, M.D.
J. Russ, Esq.

Resident and other Contributing Fellows (9).

Sir Charles Lemon, Bart.
Rev. J. Carne.
General Mackintosh.
H. E. Moore, Esq.
Lord Wensleydale.
F. D. P. Astley, Esq.
G. R. Burnell, Esq.
J. Scott, Esq.
J. Lister, Esq.

Non-contributing Fellows (4)

Sir David Brewster, K.H.
E. Francfort, M.D.
Marcus Huish.
Rev. J. G. Cumming.

Foreign Member (1).

Prof. Gmelin.

Foreign Correspondents (4).

M. A. Morlot.
Count Della Marmora.
M. Boucher de Perthes.
Prof. Hörnes.

FELLOWS RESIGNED (5).

Sir J. Boileau, Bart.
Lieut. H. Hozier.
Rev. Dr. Dendy.
J. Jones, Esq.
Rev. B. W. Gibsone.

The following Personage was elected a Foreign Correspondent during the year 1868.

M. A. Gaudry, of Paris.

The following Persons were elected Fellows during the year 1868.

January 8th.—Francis Fedden, Esq., Geological Survey of India; Major Sir George Wingate, K.C.S.I., late of the Bombay Engineers, Crofton, Hants; and John Baldry Redman, Esq., M.I.C.E., 6 Westminster Chambers, Victoria Street, S.W.

—— 22nd.—James Trubshaw Johnson, Esq., Mining and Civil Engineer, Lichfield, Staffordshire; and Stephen Brown Dixon, Jun., Esq., Pewsey, Wilts.

February 5th.—Arthur Humphrys Foord, Esq., 12 Woodlands Terrace, Blackheath; Rev. Robert Hunter, M.A., 9 Mecklenburgh Street, W.C.; Frederick Newman, Esq., Civil Engineer, 51 Belsize Road, St. John's Wood; and Hugh Seymour Tremenheere, Esq., Tremenheere, Cornwall.

—— 26th.—David Homfray, Esq., Port Madoc.

March 11th.—John Piggot, Jun., Esq., The Elms, Ulting Maldon, Essex.

—— 25th.—John Tyndall, LL.D., F.R.S., &c., Professor of Natural Philosophy in the Royal Institution; Allan Curr, Esq., Dora Terrace, Buxton Road, E.; and Capt. C. W. Fothergill, Royal Marine Artillery, Woolwich.

April 8th.—W. F. Webb, Esq., Newstead Abbey, Notts; The Rev. H. W. Crosskey, 10 Corunna Terrace, Glasgow; G. H. West, Esq., B.A., Christchurch, Oxford; J. Anstie, Esq., B.A., C.E., Devizes; R. H. Brunton, Esq., C.E., 84 George Street, Edinburgh; and H. B. Woodward, Esq., Geological Survey of England and Wales.

—— 22nd.—The Rev. J. Carne, Penzance; J. Whitaker Hulke, Esq., F.R.C.S., F.R.S., 10 Old Burlington Street, W.; and Lewis Thomas Lewis, Esq., Gadlys, Aberdare.

May 6th.—Rev. James Crombie, M.A., 84 St. John's Wood Terrace; Charles Judd, Esq., F.R.A.S., 3 Stoneleigh Villas, Tottenham; D. G. F. Macdonald, Esq., 4 Spring Gardens; J. S. Phené, Esq., 5 Carlton Terrace, Oakley Street, S.W.; and M. Thomson, Esq., College House, Southgate.

June 17th.—Charles Baron Clarke, Esq., F.L.S., Fellow of Queen's College, Cambridge, Barrister-at-Law, Dacca, Hindostan; and Flaxman Charles John Spurrell, Esq., Belvedere, S.E.

November 11th.—William Augustus Edmond Ussher, Esq., Geological Survey of England and Wales; Rev. Robert Dixon, M.A., Nottingham; William Woodman, Esq., The Deanery, Great Marlow, Bucks; and F. R. Mallet, Esq., Geological Survey of India.

December 9th.—Arthur Champernowne, Esq., M.A., Dartington Hall, Totnes, Devon; James Thomson, Esq., Glasgow; W. Chandler Roberts, Esq., F.C.S., Associate of the Royal School of Mines, Thurlow Place, Dulwich; John S. Winbolt, Esq., M.A., Sandridge Vicarage, St. Albans; Lawrence Preston, Esq., Keynshambury House, Cheltenham; John H. Blake, Esq., Geological Survey of England and Wales, 9 Aberdeen Park, Highbury, N.; John Hewitt Wheatley, Esq., Abbey View, Sligo; Owen Rees, Esq., 26 Albemarle Street, W.; and Octavius Russell Fabian, Esq., 5 Bruce Terrace, Lordship Lane, Tottenham.

December 23rd.—Rev. J. F. Blake, M.A., Gonville and Caius College, Cambridge; Thomas Sparke Parry, Esq., Castlebar, Ealing, W.; and William H. Penning, Esq., Geological Survey of England and Wales.

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

British Specimens.

Fossils from the Red Crag; presented by Sir Charles Lyell, Bart., M.A., F.R.S., F.G.S.

Specimens of Flint Flakes from Antrim; presented by the late G. V. du Noyer, Esq., through Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

Foreign Specimens.

Specimens of *Pectunculus glycimeris* from Bordeaux; presented by Sir Charles Lyell, Bart., M.A., F.R.S., F.G.S.

Tertiary Shells from Spain; presented by T. G. B. Lloyd, Esq., F.G.S.

Fossil Plants from Madeira; presented by Sir Charles Lyell, Bart., M.A., F.R.S., F.G.S.

Jurassic Fossils from South Africa; presented by Major Rocke, Her Majesty's 2nd Regiment.

Fossils from Scinde; presented by Major Rocke, Her Majesty's 2nd Regiment.

Specimen of Artificial Trachyte, made from Dolerite; presented by Dr. Mohr.

Maps, Charts, etc. presented.

Geological Survey Maps of the Netherlands, 2 Sheets (Nos. 22 and 27); presented by His Excellency the Ambassador for the Netherlands.

Geological Map of the South-east of England, from the Report of the Medical Officer of the Privy Council; presented by W. Whitaker, Esq., F.G.S.

Geological Map of South Devon, by Harvey B. Holl, M.D., F.G.S.; presented by the author.

Ordnance-Survey Maps of England, 1-inch scale, Sheets 101, 106, 109: 6-inch scale, Cumberland, Sheets 1–29: County Indexes for Cumberland and Westmoreland; presented by the Secretary of State for War.

Ordnance-Survey Maps of Scotland, 1-inch scale, Sheet 38: 6-inch scale, Kincardine, Sheets 1–27: County Indexes for Dumbarton, Lanark, and Forfar; presented by the Secretary of State for War.

Ordnance-Survey Maps of Ireland, 1-inch scale, Sheets 15, 19, 42, 100, 110; presented by the Secretary of State for War.

Geologische Uebersichtskarte der österreichischen Monarchie, Sheets 6 and 10, by F. R. von Hauer; presented by the author.

Geological Survey of Victoria, Maps 5 N.W., 14 S.W., 51 S.W., and Section of N.E. corner of 14 S.W.; presented by the Director of the Geological Survey of Victoria.

Sveriges Geologiska Undersökning, Sheets 22–25; presented by the Director, Prof. A. Erdmann.

The following Lists contain the Names of Persons and Public Bodies from whom the Society has received Donations to the Library and Museum since the last Anniversary, February 21, 1868.

I. List of Societies and Public Bodies from whom Donations of Books have beeen received since the last Anniversary Meeting.

Basel, Natural History Society of.

Bath, Natural History and Antiquarian Field Club of.

Berlin. German Geological Society.

——. Royal Prussian Academy.

Berwick. Berwickshire Naturalists' Field Club.

Bordeaux, Society of Physical and Natural Sciences of.

Boston, Society of Natural History of.

Bremen, Natural-History Society of.

Breslau. Silesian Society.

Brussels. Royal Academy of Belgium.

——, Royal Observatory of.

Calcutta. Asiatic Society of Bengal.

Cambridge, Philosophical Society of.

Chicago, Academy of Sciences of.

Christiania, Royal Academy of.

——, University of.

Copenhagen. Royal Danish Academy.

Darmstadt. Geological Society of the Middle Rhine.

Devonshire. Scientific Association.

Dorpat, Natural-History Society of.

Dresden, (Isis) Natural-History Society of.

Edinburgh, Royal Physical Society of.
——, Royal Society of.

Florence. Italian Society of Natural Sciences.

Geneva, Physical and Natural-History Society of.
German Scientific Association.
Glasgow, Geological Society of.

Halifax. Nova-Scotian Institute of Natural History.
Harvard College.
Heidelberg, Natural-History and Medical Society of.
Hessian Government.

Indian Government.

Lausanne. Vaudoise Society of Natural Sciences.
Leeds, Literary and Philosophical Society of.
Liége, Royal Society of Sciences of.
Liverpool, Geological Society of.
——, Literary and Philosophical Society of.
London, Anthropological Society of.
——, Art Union of.
——. British Association.
——. Chemical Society.
——. Geological Survey.
——. Geologists' Association.
——. Institute of Actuaries.
——. Linnean Society.
——. Mendicity Society.
——. Palæontographical Society.
——. Photographic Society.
——. Ray Society.
——. Royal Asiatic Society of Great Britain.
——. Royal Astronomical Society.
——. Royal College of Physicians.
London. Royal College of Surgeons.
——. Royal Geographical Society.
——. Royal Horticultural Society.
——. Royal Institution.
——. Royal Microscopical Society.
——. Royal Society.
——. Society of Arts.
——. Victoria Institute.
——. War Office.
——, Zoological Society of.
Lund, University of.
Lyons, Academy of.

Manchester, Geological Society of.
Melbourne. Geological Survey of Victoria.
——. Mining Survey of Victoria.
——, National Museum of.
——. Royal Society of Victoria.
Milan. Royal Lombard Institute.
Montreal. Geological Survey of Canada.
——, Natural-History Society of.
Moscow, Imperial Society of Naturalists of.

Neuchâtel, Society of Natural Sciences of.
New York, Lyceum of Natural History of.
——, State Cabinet of.
New Zealand, Geological Survey of.

Offenbach. Natural-History Society of.

Palermo, Institute of Natural Sciences of.
Paris. Academy of Sciences.
——. Geological Society of France.
——, Museum of Natural History of.

Philadelphia, Academy of Natural Sciences of.
——. American Academy.
——. American Philosophical Society.
Plymouth Institution.
Presburg, Natural-History Society of.

Salem. Essex Institute.
St. Louis, Academy of.
St. Petersburg, Academy of Sciences of.
Stockholm. Royal Swedish Academy.
Stuttgart. Natural-History Society of Würtemberg.

Teignmouth. Teign Naturalists' Field Club.

Turin, Royal Academy of Sciences of.

United States, Patent Office of.

Vienna, Imperial Academy of Sciences of.
——, Geological Institute of.

Warwickshire. Naturalists' Field Club.
Woolhope. Naturalists' Field Club.
Würzburg, Natural-History and Medical Society of.

Yorkshire, Geological and Polytechnic Society of the West Riding of.

II. List containing the names of Persons from whom Donations to the Library and Museum have been received since the last Anniversary.

Abich, Dr. H., F.M.G.S.
American Journal of Science, Editors of the.
American Naturalist, Editors of the.
Anderson, Dr. T.
Anglo-Colonial Magazine, Editor of the.
Annales des Mines, Editors of the.
Archiardi, Sign. A. d'.

Baily, W. H., Esq., F.G.S.
Barkas, T. P., Esq.
Barrande, M. J., F.M.G.S.
Biedermann, M. W. A. E.
Billing, Dr., F.G.S.
Blackwood, Messrs.
Bland, T., Esq.
Brand, Dr.
Brown, R., Esq.
Briart, M.
Burgess, J., Esq.
Canadian Journal, Editors of the.

Capper, R., Esq.
Carpenter, Dr. W. B., F.G.S.
Chavannes, M.
Chemical News, Editor of the.
Christy, H., Esq., Executors of the late.
Colliery Guardian, Editor of the.
Collomb, M. E.
Cornet, M.
Croll, J., Esq.

Dahll, T., Esq., F.G.S.
Darbishire, R. D., Esq., F.G.S.
Dawson, Dr. J. W., F.G.S.
Dechen, H. von., F.M.G.S.
Delesse, M., F.M.G.S.
Delgado, M. F. J. N.
D'Orbigny, M. C.
Dorna, Prof. A.
Duncan, Dr. P. Martin, Sec. G.S.
Du Noyer, G. V., Esq.

Egerton, Sir P. de M. G., Bart., M.P., F.G.S.

Erdmann, Dr.

Fairman, E. St. John, Esq., F.G.S.
Favre, M. A., F.C.G.S.
Foster, C. Le Neve, Esq., F.G.S.
Fouqué, M.
Fuchs, M. T.

Gastaldi, Prof. B.
Gaudry, M. A., F.C.G.S.
Geological and Natural-History Repertory, Editor of the.
Geological Magazine, Editors of the.
Goebel, M. A.
Griesbach, M. K.
Gümbel, Dr.
Guppy, R. J. L., Esq., F.G.S.

Haidinger, Prof. W. von, F.M.G.S.
Hall, J., Esq., F.M.G.S.
Hall, J. M., Esq., F.G.S.
Halloy, M. J. J. d'Omalius d', F.M.G.S.
Hauer, F. Ritter von, F.C.G.S.
Heer, Dr. Oswald, F.C.G.S.
Helmersen, General G. von, F.M.G.S.
Hilgendorf, Dr. F.
Hoenen, M. A. von.
Hope, B., Esq.
Hörnes, Dr., F.C.G.S.
Hyatt, A. Esq.

Jeffreys, J. Gwyn, Esq., Treas. G.S.
Jenzsch, Dr. G.
Jones, Prof. T. R., F.G.S.
Journal of Travel and Natural History, Editor of the.

Karrer, Dr. F.
King, Dr. W.
Koenen, M. A. von.

Lartet, M. E., F.M.G.S.
Laube, Dr. G. C.
Lea, I., Esq.
Lemberg, J. von.
Lloyd, T. G. B., Esq., F.G.S.
London, Edinburgh, and Dublin Philosophical Magazine, Editors of the.
London Review, Editor of the.
Longman and Co., Messrs.
Lyell, Sir Charles, Bart., F.G.S.

M'Donald, Prof. W., F.G.S.
Marcou, M. J.
Marsh, Prof. O. C., F.G.S.
Martins, M. C., F.C.G.S.
Medical Press and Circular, Editor of the.
Mining Gazette, Editors of the.
Mohr, Dr.
Monthly Microscopical Journal, Editor of the.
Moore, J. Scott, Esq.
Morlot, M. A., F.C.G.S.

Naturalist's Note Book, Editor of the.
Naumann, Prof. C., F.M.G.S.
Newberry, J. S., Esq.
Nicholson, Dr. H. A., F.G.S.
Nielreich, Dr. A.
Nystrom, J. W.

Oldham, Dr. T., F.G.S.
Omboni, Sign. M. G.
Owen, Prof. R., F.G.S.

Pessina, Sign. L. J.
Peters, Dr. Karl F.
Phillips, Prof. J., F.G.S.
Pictet, M. F. J., F.C.G.S.
Pourtales, Count L. de.

Quarterly Journal of Microscopic Science, Editors of the.
Quarterly Journal of Science, Editors of the.
Quetelet, M. A.

Rasumowskoje, M.
Renard, Dr.
Renevier, M. E.
Reuss, Prof. A. E., F.C.G.S.
Reynes, M. P.
Rocke, Major.

Roper, F. C. S., Esq., F.G.S.
Ruprecht, J. F.

Sars, Prof. M.
Schill, M.
Schloenbach, Dr. U.
Schumann, M. J.
Scientific Opinion, Editor of.
Seebach, Dr. H. von.
Silliman, Prof.
Student and Intellectual Observer, Editor of the.
Studer, Prof. B., F.M.G.S.
Suess, Prof. E., F.C.G.S.
Sumner, Hon. C.

Tchihatcheff, M. P. de.
Teale, J., Esq.
Topley, W., Esq., F.G.S.
Trautschold, M. H.

Wanklyn, A., Esq.
Whitaker, W., Esq., F.G.S.
Whitley, N., Esq.
Winnertz, Dr. J.

Zigno, Baron A. de, F.C.G.S.
Zittel, M.

List of PAPERS *read since the last Anniversary Meeting, February* 21*st*, 1868.

1868.

February 26th.—Observations on the Parallel Roads of Glen Roy, by Charles Babbage, Esq., F.R.S.

———— On the Origin of Smoothed, Rounded, and Hollowed Surfaces of Limestone and Granite, by D. Mackintosh, Esq., F.G.S.

———— On a striking Instance of Apparent Oblique Lamination in Granite, by D. Mackintosh, Esq., F.G.S.

———— On the Mode and Extent of Encroachment of the Sea on some parts of the Shores of the Bristol Channel, by D. Mackintosh, Esq., F.G.S.

———— On the Two Plains of Hertfordshire and their Gravels, by T. McK. Hughes, Esq., M.A., F.G.S.

March 11th.—On the Structure of the Crag-beds of Norfolk and Suffolk, with some Observations on their Organic Remains—Part I. Coralline Crag, by Joseph Prestwich, Esq., F.R.S., F.G.S., &c.

March 25th.—On some New Species of Crustacea from the Upper Silurian Rocks of Lanarkshire &c., and further Observations on the Structure of *Pterygotus*, by Henry Woodward, Esq., F.G.S.

———— On the Coniston Group, by Professor R. Harkness, F.R.S., F.G.S., and H. A. Nicholson, D.Sc., M.B., F.G.S.

———— On the Death of Fishes on the coast of the Bay of Fundy, by A. Leith Adams, M.B., F.G.S.

———— On Volcanoes in the New Hebrides and Banks's Islands, by the Rev. Joseph Atkin; communicated by T. Codrington, Esq., F.G.S.

April 8th.—On the Affinities and probable Habits of the extinct Australian Marsupial, *Thylacoleo carnifex*, Owen, by W. H. Flower, Esq., F.R.C.S., F.R.S., F.G.S., &c.

1868.

April 8th.—On the Thickness of the Carboniferous Rocks of the Pendle Range of Hills, Lancashire, as illustrating the Author's views regarding the "South-easterly Attenuation of the Carboniferous Sedimentary Strata of the North of England," by Edward Hull, Esq., M.A., F.R.S., F.G.S.

——— Observations on the Relative Ages of the Leading Physical Features and Lines of Elevation of the Carboniferous District of Lancashire and Yorkshire. By Edward Hull, Esq., M.A., F.R.S., F.G.S.

——— On a Saliferous Deposit in St. Domingo, by D. Hatch, Esq.; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

April 22nd.—On the Disposition of Iron in variegated Strata, by George Maw, Esq., F.L.S., F.G.S., &c.

——— On the Older Rocks of South Devon and East Cornwall, by Harvey B. Holl, M.D., F.G.S.

May 6th.—On the Quaternary Gravels of England. By Alfred Tylor, Esq., F.L.S., F.G.S.

May 20th.—On the Eruption of the Kaimeni of Santorin, by Dr. J. S. Julius Schmidt; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— On the Structure of the Crag-beds of Norfolk and Suffolk, with some Observations on their Organic Remains—Part II. The Red Crag of Suffolk, by Joseph Prestwich, Esq., F.R.S., F.G.S..

June 3rd.—On some Carboniferous corals, by James Thomson, Esq.; communicated by Dr. P. M. Duncan, F.R.S., Sec. G.S.

——— On the Pebble-beds of Middlesex, Essex, and Herts, by Searles V. Wood, Jun., Esq., F.G.S.

——— On the Lower Cretaceous Beds of the Bas-Boulonnais, with Notes on their English equivalents, by William Topley, Esq., F.G.S.

——— Note on the Mendip Anticlinal, by C. H. Weston, Esq., F.G.S.

June 17th.—On the Distribution of Stone Implements in Southern India, by R. Bruce Foote, Esq., F.G.S.

——— On worked Flints from Carrickfergus and Larne, by G. V. Du Noyer, Esq.; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— On the Diminution of the Volume of the Sea during past Geological Epochs, by Andrew Murray, Esq., F.L.S.; communicated by the President.

——— Has the Asiatic Elephant been found in a Fossil State?, by A. Leith Adams, M.B., F.G.S.; with some Additional Remarks, by G. Busk, Esq., F.R.S., F.G.S.

——— On the Characters of some new Fossil Fish from the Lias of Lyme Regis, by Sir Philip de M. Grey Egerton, Bart, M.P., F.R.S., F.G.S.

1868.

June 17th.—Note accompanying some Fossils from Port Santa Cruz, Patagonia, by Capt. Thomas Baker; communicated by H. M. Jenkins, Esq., F.G.S.

——— On Jurassic Deposits in the North-west Himalaya, by Ferdinand Stoliczka, Ph.D., F.G.S.

——— On a true Coal-plant (*Lepidodendron*) from Sinai, by J. W. Salter, Esq., A.L.S., F.G.S.

——— On some Fossils from the Menevian Group, by J. W. Salter, Esq., A.L.S., F.G.S., and H. Hicks, Esq.

——— Report of recent Earthquakes in Northern Formosa, by H. F. Holt, Esq.; communicated by the Secretary of State for Foreign Affairs.

——— Memorandum on the Coal-Mines of Iwanai, Island of Jesso, Japan, by A. B. Mitford, Esq.; communicated by the Secretary of State for Foreign Affairs.

——— On a New Species of Fossil Deer from Clacton, by W. Boyd Dawkins, Esq., M.A. F.R.S., F.G.S.

——— On a New Species of Deer from the Norwich Crag, by W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.

——— Notes to accompany a Section of the Strata from the Chalk to the Bembridge Limestone at Whitecliff Bay, Isle of Wight, by T. Codrington, Esq., F.G.S.

——— On the Graptolites of the Coniston Flags; with Notes on the British Species of the Genus *Graptolites*, by H. A. Nicholson, D.Sc., M.B., F.G.S.

——— On the "Waterstone Beds" of the Keuper, and on Pseudomorphous Crystals of Chloride of Sodium, by G. W. Ormerod, Esq., M.A., F.G.S.

——— On the Discovery of the Remains of Cephalaspidian Fishes in Devonshire and Cornwall, and on the Identity of *Steganodictyum*, M'Coy, with genera of those Fishes, by E. Ray Lankester, Esq., Chr. Ch. Oxford; communicated by H. Woodward, Esq., F.G.S.

——— On the Geological Peculiarities of that part of Central Germany known as the Saxon Switzerland, by the late James Clark, Esq.; communicated by Sir R. I. Murchison, Bart, K.C.B., F.R.S., V.P.G.S.

November 11th.—Note comparing the Geological Structure of North-western Siberia with that of Russia in Europe, by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— On a Section of a Well at Kissingen, by Dr. F. Sandberger, For. Corr. G.S.; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— On the Formation of Deltas, and on the Evidence and Cause of great Changes in the Sea-level during the Glacial Period, by Alfred Tylor, Esq., F.L.S., F.G.S.

November 25th.—On Floods in the Island of Bequia, by G. M. Browne, Esq.; communicated by the Secretary of State for Foreign Affairs.

1868.

November 25th.—Description of Nga Tutura, an extinct Volcano in New Zealand, by Capt. F. W. Hutton, F.G.S.

——— On *Dakosaurus*, by J. Wood Mason, Esq., F.G.S.

——— On the Anatomy of the Test of *Amphidetus* (*Echinocardium*) *Virginianus*, Forbes, and on the Genus *Breynia*, by P. Martin Duncan, M.B., F.R.S., Sec. G.S.

December 9th.—Note on a Geological Reconnaissance made in Arabia Petræa in the Spring of 1868, by H. Bauerman, Esq., F.G.S.

——— On the Occurrence of Celestine in the Nummulitic Limestone of Egypt, by H. Bauerman, Esq., F.G.S., and C. Le Neve Foster, D.Sc., B.A., F.G.S.

——— Note on the Echinodermata, Bivalve Mollusca, and some other Fossil species from the Cretaceous Rocks of Sinai, by Dr. P. Martin Duncan, F.R.S., Sec. G.S.

——— On the Existence during the Quaternary Period of a Glacier of the Second Order occupying the "Cirque" of the Valley of Palhères, in the Western part of the Granitic "Massif" of the Lozère, by M. Charles Martins, For. Corr. G.S.

December 23rd.—On the so-called "Eozoonal" Rock, by Prof. W. King and Dr. T. H. Rowney; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— Notes on the Geology of China, with more especial reference to the provinces of the Lower Yungtsi, by Thomas W. Kingsmill, Esq.; communicated by the President.

1869.

January 13th.—On *Hyperodapedon*, by Prof. T. H. Huxley, LL.D., F.R.S., Pres. G.S.

——— On the Locality of a new Specimen of *Hyperodapedon* on the South Coast of Devon, by W. Whitaker, Esq., F.G.S.

January 27th.—Notes on Graptolites and allied Fossils occurring in Ireland, by W. H. Baily, Esq., F.G.S.

——— Notice of Plant-remains from beds interstratified with the Basalt in the County of Antrim, by W. H. Baily, Esq., F.G.S.

——— Remarks upon the Basalt Dykes of the Mainland of India opposite to the Islands of Bombay and Salsette, by G. T. Clark, Esq., F.G.S.

——— On Auriferous Rocks in South-eastern Africa, by Dr. Sutherland; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

February 10th.—On the Evidence of a Ridge of Lower Carboniferous Rocks crossing the Plain of Cheshire beneath the Trias, and forming the Boundary between the Permian Rocks of the Lancashire type on the North, and those of the Salopian type on the South, by Edward Hull, Esq., M.A., F.R.S., F.G.S.

——— On the Red Chalk of Hunstanton, by the Rev. T. Wiltshire, M.A., F.L.S., 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,—

That the thanks of the Society be given to the Earl of Selkirk and Professor Ramsay, retiring from the office of Vice-President.

That the thanks of the Society be given to the Duke of Argyll, R. Etheridge, Esq., Professor Ramsay, Col. Sir Henry James, R.E., and Robert W. Mylne, 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 the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Professor T. H. Huxley, LL.D., F.R.S.

VICE-PRESIDENTS.

Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
Sir R. I. Murchison, Bart, K.C.B., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Rev. T. Wiltshire, M.A., F.L.S.

SECRETARIES.

P. Martin Duncan, M.B., F.R.S.
John Evans, Esq., F.R.S.

FOREIGN SECRETARY.

Prof. D. T. Ansted, M.A., F.R.S.

TREASURER.

J. Gwyn Jeffreys, Esq., F.R.S.

COUNCIL.

Prof. D. T. Ansted, M.A., F.R.S.
W. Boyd Dawkins, Esq., M.A., F.R.S.
P. Martin Duncan, M.B., F.R.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
John Evans, Esq., F.R.S., F.S.A.
David Forbes, Esq., F.R.S.
J. Wickham Flower, Esq.
R. A. C. Godwin-Austen, Esq., F.R.S.
Harvey B. Holl, M.D.
Prof. T. H. Huxley, LL.D., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S.
Prof. T. Rupert Jones.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
John Carrick Moore, Esq., M.A., F.R.S.
Prof. John Morris.
Sir R. I. Murchison, Bart., K.C.B., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Earl of Selkirk, F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Alfred Tylor, Esq., F.L.S.
Rev. Thomas Wiltshire, M.A., F.R.A.S.
Searles V. Wood, Jun., Esq.
Henry Woodward, Esq., F.Z.S.

LIST OF

THE FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1868.

Date of Election.

1819. Count A. Breunner, *Vienna.*
1822. Count Vitaliano Borromeo, *Milan.*
1827. Dr. H. von Dechen, *Bonn.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R.S., *Paris.*
1829. Dr. Ami Boué, *Vienna.*
1829. Dr. J. J. d'Omalius d'Halloy, *Halloy, Belgium.*
1839. Dr. Ch. G. Ehrenberg, For. Mem. R.S., *Berlin.*
1840. Professor Adolphe T. Brongniart, For. Mem. R.S., *Paris.*
1840. Professor Gustav Rose, *Berlin.*
1841. Dr. Louis Agassiz, For. Mem. R.S., *Cambridge, Massachusetts.*
1841. Professor G. P. Deshayes, *Paris.*
1844. William Burton Rogers, Esq., *Boston, U.S.*
1844. M. Edouard de Verneuil, For. Mem. R.S., *Paris.*
1847. M. le Vicomte B. d'Archiac, *Paris.*
1848. James Hall, Esq., *Albany, State of New York.*
1850. Professor Bernard Studer, *Berne.*
1850. Herr Hermann von Meyer, *Frankfort-on-Maine.*
1851. Prof. James D. Dana, *New Haven, Connecticut.*
1851. General G. von Helmersen, *St. Petersburg.*
1851. Dr. W. K. von Haidinger, For. Mem. R.S., *Vienna.*
1851. Professor Angelo Sismonda, *Turin.*
1853. Count Alexander von Keyserling, *Dorpat.*
1853. Prof. L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Prof. Carl Friedrich Naumann, *Leipsic.*
1856. Prof. Robert W. Bunsen, For. Mem. R.S., *Heidelberg.*
1857. Prof. H. R. Goeppert, *Breslau.*
1857. M. E. Lartet, *Paris.*
1857. Prof. H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *Tiflis, Georgia.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. Prof. A. Delesse, *Paris.*
1859. Dr. Ferdinand Roemer, *Breslau.*
1860. Dr. H. Milne-Edwards, For. Mem. R.S., *Paris.*
1861. Prof. Gustav Bischof, *Bonn.*
1862. Baron Sartorius von Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*

1864. Prof. Paolo Savi, *Pisa.*
1865. M. Jules Desnoyers, *Paris.*
1866. Dr. Joseph Leidy, *Philadelphia.*
1867. Prof. A. Daubrée, *Paris.*

LIST OF

THE FOREIGN CORRESPONDENTS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1868.

Date of Election.

1863. Prof. E. Beyrich, *Berlin.*
1863. M. Boucher de Perthes, *Abbeville.*
1863. Herr Bergmeister Credner, *Gotha.*
1863. M. E. Desor, *Neuchâtel.*
1863. Prof. Alphonse Favre, *Geneva.*
1863. Signor B. Gastaldi, *Turin.*
1863. M. Paul Gervais, *Montpellier.*
1863. Herr Bergrath Gümbel, *Munich.*
1863. Dr. Franz Ritter von Hauer, *Vienna.*
1863. Prof. E. Hébert, *The Sorbonne, Paris.*
1863. Rev. Dr. O. Heer, *Zurich.*
1863. Dr. Moritz Hörnes, *Vienna.*
1863. Dr. G. F. Jäger, *Stuttgart.*
1863. Dr. Kaup, *Darmstadt.*
1863. M. Nikolai von Kokscharow, *St. Petersburg.*
1863. M. Lovén, *Stockholm.*
1863. Lieut.-Gen. Count Alberto Ferrero della Marmora, *Turin.*
1863. Count A. G. Marschall, *Vienna.*
1863. Prof. G. Meneghini, *Pisa.*
1863. M. Morlot, *Berne.*
1863. M. Henri Nyst, *Brussels.*
1863. Prof. F. J. Pictet, *Geneva.*
1863. Signor Ponzi, *Rome.*
1863. Prof. Quenstedt, *Tübingen.*
1863. Prof. F. Sandberger, *Bavaria.*
1863. Signor Q. Sella, *Turin.*
1863. Dr. F. Senft, *Eisenach.*
1863. Dr. B. Shumard, *St. Louis, Missouri.*
1863. Prof. E. Suess, *Vienna.*
1863. Marquis de Vibraye, *Paris.*
1864. M. J. Bosquet, *Maestricht.*

1864. Dr. Theodor Kjerulf, *Christiania.*
1864. Dr. Steenstrup, *Copenhagen.*
1864. Dr. Charles Martins, *Montpellier.*
1865. Dr. C. Nilsson, *Stockholm.*
1866. Prof. J. P. Lesley, *Philadelphia.*
1866. M. Victor Raulin, *Paris.*
1866. Prof. August Emil Reuss, *Vienna.*
1866. Baron Achille de Zigno, *Padua.*
1867. Prof. Bernhard Cotta, *Freiburg.*
1868. M. Albert Gaudry, *Paris.*

AWARDS OF THE WOLLASTON MEDAL

UNDER THE CONDITIONS OF THE "DONATION-FUND"

ESTABLISHED BY

WILLIAM HYDE WOLLASTON, M.D., F.R.S., F.G.S., &c.,

"To promote researches concerning the mineral structure of the earth, and to enable the Council of the Geological Society to reward those individuals of any country by whom such researches may hereafter be made,"—"such individual not being a Member of the Council."

1831. Mr. William Smith.
1835. Dr. G. A. Mantell.
1836. M. L. Agassiz.
1837. Capt. P. T. Cautley. / Dr. H. Falconer.
1838. Professor R. Owen.
1839. Professor C. G. Ehrenberg.
1840. Professor A. H. Dumont.
1841. M. Adolphe T. Brongniart.
1842. Baron L. von Buch.
1843. M. E. de Beaumont. / M. P. A. Dufrénoy.
1845. The Rev. W. D. Conybeare.
1845. Professor John Phillips.
1846. Mr. William Lonsdale.
1847. Dr. Ami Boué.
1848. The Rev. Dr. W. Buckland.
1849. Mr. Joseph Prestwich.
1850. Mr. William Hopkins.
1851. The Rev. Prof. A. Sedgwick.
1852. Dr. W. H. Fitton.
1853. M. le Vicomte A. d'Archiac. / M. E. de Verneuil.
1854. Dr. Richard Griffith.
1855. Sir H. T. De la Beche.
1856. Sir W. E. Logan.
1857. M. Joachim Barrande.
1858. Herr Hermann von Meyer. / Mr. James Hall.
1859. Mr. Charles Darwin.
1860. Mr. Searles V. Wood.
1861. Prof. Dr. H. G. Bronn.
1862. Mr. Robert A. C. Godwin-Austen.
1863. Prof. Gustav Bischof.
1864. Sir R. I. Murchison.
1865. Mr. Thomas Davidson.
1866. Sir Charles Lyell.
1867. Mr. G. P. Scrope.
1868. Prof. Carl F. Naumann.
1869. Mr. H. C. Sorby.

AWARDS

OF THE

BALANCE OF THE PROCEEDS OF THE WOLLASTON "DONATION-FUND."

1831. Mr. William Smith.
1833. Mr. William Lonsdale.
1834. M. Louis Agassiz.
1835. Dr. G. A. Mantell.
1836. M. G. P. Deshayes.
1838. Professor Richard Owen.
1839. Professor C. G. Ehrenberg.
1840. Mr. J. De Carle Sowerby.
1841. Professor Edward Forbes.
1842. Professor John Morris.
1843. Professor John Morris.
1844. Mr. William Lonsdale.
1845. Mr. Geddes Bain.
1846. Mr. William Lonsdale.
1847. M. Alcide d'Orbigny.
1848. { Cape of Good Hope Fossils. M. Alcide d'Orbigny. }
1849. Mr. William Lonsdale.
1850. Professor John Morris.
1851. M. Joachim Barrande.
1852. Professor John Morris.
1853. M. L. de Koninck.
1854. Mr. S. P. Woodward.
1855. Drs. G. and F. Sandberger.
1856. M. G. P. Deshayes.
1857. Mr. S. P. Woodward.
1858. Mr. James Hall.
1859. Mr. Charles Peach.
1860. { Mr. T. Rupert Jones. Mr. W. K. Parker. }
1861. Professor A. Daubrée.
1862. Professor Oswald Heer.
1863. Professor Ferdinand Senft.
1864. Professor G. P. Deshayes.
1865. Mr. J. W. Salter.
1866. Mr. Henry Woodward.
1867. Mr. W. H. Baily.
1868. M. J. Bosquet.
1869. Mr. W. Carruthers.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions for Quarterly Journal (considered good)	25	0	0			
Due for Authors' Corrections	30	0	0			
Due for Arrears (See Valuation-sheet)	300	0	0			
				355	0	0
Estimated Ordinary Income for 1869.						
Annual Contributions :—						
From Resident Fellows, and Non-residents of 1859 to 1861				750	0	0
Admission-fees (supposed)				225	0	0
Compositions (supposed)				300	0	0
Dividends on Consols				149	13	2
Sale of Transactions, Proceedings, Library-catalogues, and Ormerod's Index	7	10	0			
Sale of Quarterly Journal	200	0	0			
Sale of Geological Map	20	0	0			
				227	10	
Due from Longman and Co. in June	49	13	7			
Due from Stanford and Co. in June	15	19	3			
				65	12	10
				£2072	16	0

J. GWYN JEFFREYS, TREAS.

Jan. 26, 1869.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes and Insurance	80	0	0			
Furniture	15	0	0			
House-repairs	40	0	0			
Fuel	36	0	0			
Light	30	0	0			
Miscellaneous House-expenses	60	0	0			
Stationery	35	0	0			
Miscellaneous Printing, including Abstracts	75	0	0			
Tea for Meetings	20	0	0			
				391	0	0
Salaries and Wages:						
Assistant Secretary	200	0	0			
Clerk	100	0	0			
Assistants in Library and Museum	77	0	0			
Porter	100	0	0			
Housemaid	40	0	0			
Occasional Attendants	10	0	0			
Collector	20	0	0			
Accountant	5	0	0			
				552	0	0
Library	100	0	0			
Museum	10	0	0			
				110	0	0
Miscellaneous Scientific Expenditure				75	0	0
Diagrams at Meetings				5	0	0
Publications: Quarterly Journals	650	0	0			
,, Geological Map	20	0	0			
,, Ormerod's Index	90	0	0			
				760	0	0
Balance in favour of the Society				179	16	0
				£2072	16	0

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Banker's January 1, 1868	395	4	6			
Balance in Clerk's hands	5	8	4			
				400	12	10
Compositions received				341	8	0
Arrears of Admission-fees	63	0	0			
Admission-fees, 1868	226	16	0			
				289	16	0
Arrears of Annual Contributions				196	8	6
Annual Contributions for 1868, viz. :—						
Resident Fellows	£696	3	0			
Non-Resident Fellows ...	40	19	0			
				737	2	0
Annual Contributions in advance..................				12	16	6
Journal Subscriptions in advance				1	19	0
Dividends on Consols				149	13	2
Publications:						
Sale of Transactions..........................	5	2	0			
Sale of Journal, Vols. 1–23	163	15	4			
,, Vol. 24*	115	13	10			
Sale of Geological Map	21	11	0			
Sale of Library-catalogues	1	15	0			
Sale of Ormerod's Index..................	0	16	0			
				308	13	2
				£2438	9	2

We have compared the Books and Accounts presented to us, and found them correct.

(Signed) JOSEPH PRESTWICH, ALFRED TYLOR, } *Auditors.*

Jan. 26, 1869.

	£	s.	d.
* Due from Messrs. Longman, in addition to the above, on Journal, Vol. 24, &c.	49	13	7
Due from Fellows for Journal subscriptions, estimated........	25	0	0
Due from Messrs. Stanford on Geological Map	15	19	3
	£90	12	10

Year ending December 31st, 1868.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	48	6	3			
Fire-insurance	9	0	0			
New Furniture	17	19	6			
House-repairs	36	0	9			
Fuel	35	5	0			
Light	27	11	9			
Miscellaneous House-expenses	54	7	2			
Stationery	12	1	3			
Miscellaneous Printing	52	0	0			
Tea at Meetings	19	8	6			
				312	0	2
Salaries and Wages:						
Assistant-Secretary	300	0	0			
Clerk	80	0	0			
Library and Museum Assistants	143	3	4			
Porter	100	0	0			
Housemaid	40	0	0			
Occasional attendants	37	5	0			
Collector	39	4	7			
Accountants	5	0	0			
				744	12	11
Library				76	2	5
Museum				8	14	10
Miscellaneous Scientific Expenses				94	18	4
Diagrams at Meetings				9	6	9
Publications:						
Geological Map	8	16	1			
Journal, Vols. 1–23	157	1	9			
„ Vol. 24	614	15	5			
				780	13	3
Balance at Banker's, Dec. 31, 1868	376	13	5			
Balance in Clerk's hands, Dec. 31, 1868	35	7	1			
				412	0	6
				£2438	9	2

Trust-Account.

Receipts.	£	s.	d.
Balance at Banker's, January 1, 1868, on the Wollaston Donation-fund	31	19	6
Dividends on the Donation-fund for 1868 on Reduced 3 per Cents.	31	14	2
	£63	13	8

Payments.	£	s.	d.
Award to M. Bosquet	21	9	6
Cost of striking Gold Medal awarded to Prof. Carl F. Naumann	10	10	0
Balance at Banker's, Dec. 31, 1868 (Wollaston-fund)	31	14	2
	£63	13	8

Valuation of the Society's Property; 31*st December*, 1868.

Property.	£	s.	d.	£	s.	d.
Due from Longman & Co., on acc. of Journ. Vol. XXIV., &c.				49	13	7
Due from Stanford, on account of Map				15	19	3
Due from Subscribers to Journal (considered good)				25	0	0
Due for Authors' Corrections in Journal				30	0	0
Balance in Banker's hands, Dec. 31, 1868				376	13	5
Balance in Clerk's hands, Dec. 31, 1868				35	7	1
Funded Property:—						
Consols, at 95	5116	11	1	4860	14	6
Arrears of Admission-fees (considered good)				56	14	0
Arrears of Annual Contributions (considered good)				243	6	0
				£5693	7	10

[*N.B. The value of the Collections, Library, Furniture, and stock of unsold Publications is not here included.*]

Debts.	£	s.	d.
Cheques drawn 23rd December, 1868, and not cashed until after 31st December	12	15	7
Debts incurred previously to 31st December, and now payable	53	6	2
Balance in favour of the Society	5627	6	1
	£5693	7	10

J. GWYN JEFFREYS, *Treas.*

Jan. 26, 1869.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

19TH FEBRUARY, 1869.

AWARD OF THE WOLLASTON MEDAL.

THE Reports of the Council and of the Committees having been read, the President, Professor T. H. HUXLEY, LL.D., F.R.S., handed the Wollaston Medal to HENRY CLIFTON SORBY, Esq., F.R.S., addressing him as follows:—

Mr. SORBY,—The Council of the Geological Society has charged me with the pleasant duty of presenting to you the Wollaston Medal, in signification of the value which all geologists attach to your long-continued and laborious investigations.

For more than eighteen years you have been engaged in researches into the structure of terrestrial rocks and minerals, and of meteorites; a long series of memoirs testifies to your patience, your industry, your ingenuity, and your knowledge of the sciences which bear upon the problems you have attempted to solve; and the most competent judges bear willing witness to the light which you have thrown upon the hidden processes of nature to which these bodies owe their origin and present condition.

The value of work so honest and so searching as yours cannot be fully estimated by your contemporaries. But already we see that the explanation of slaty cleavage, to which you were led by your study of the intimate structure of the rocks which exhibit that phenomenon, is in full accordance with the conclusions of physical investigators who have approached the question from a very different side, and may now be said to be universally adopted.

And, finally, it will not escape the attention of the Society, as in marked accordance with the fitness of things, that Wollaston's Medal should be conferred upon a worker in whom is apparent so much of that love of minute research and so much of that power of elucidating the great by the little, which characterized the illustrious founder.

Mr. SORBY replied:—

Mr. PRESIDENT and GENTLEMEN,—Allow me to express my best thanks for the honour you have done me by the award of the Wollaston Medal; and allow me, Mr. President, to thank you very sincerely for the kind manner in which you have spoken of my researches. I have always contended that the greatest reward that a scientific man can receive is the pleasure attending the prosecution of original investigations; but, at the same time, no scientific man ought to be satisfied unless his inquiries lead to some valuable result. The award of the Wollaston Medal is therefore a cause of great satisfaction to me, since it shows that my labours have not been misdirected, but have met with the very high approval of the Geological Society of London.

Award of the Wollaston Donation-fund.

The President then addressed W. Carruthers, Esq., F.L.S., F.G.S., as follows:—

Mr. Carruthers,—I have much pleasure in placing in your hands the balance of the Wollaston Donation-fund, which has been awarded to you by the Council of the Geological Society, in aid of your researches in Fossil Botany.

Your investigations into this very difficult department of Biology, and more especially those which have been directed towards the structure of Fossil Fruits, have been already fraught with such valuable results that you may justly look upon this award as a well-earned testimony of our gratitude for your labours.

Still I would remind you that scientific gratitude is mainly of that sort which has been defined as "a lively sense of favours to come," and that we trust this award will aid you in conferring a long series of such favours upon us.

Mr. Carruthers replied:—

I thank the Council of the Society for the high honour they have done me in considering my work deserving of the award of the Wollaston Aid-fund, and you, Sir, for the very flattering terms in which you have conveyed it to me. It has been my good fortune to carry on my work under the eye, and with the continual assistance, of my illustrious colleague, Mr. J. J. Bennett, and to have been led into the investigation of a department of science which has long been neglected, and in which the materials have so accumulated that even the most careless gleaner must find a rich harvest to reward his efforts. The honour you have done me, and the substantial aid you have given me, I receive as increased incentives to more diligent work, and I trust that in the future I may be able to some extent to realize what you have in such flattering terms said you expect of me.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

Professor T. H. Huxley, LL.D., F.R.S.

I regret to have to announce that the list of Fellows of this Society deceased since the last Anniversary contains many distinguished names. In most cases their distinction has been won in fields not purely geological; but in the Rev. S. W. King, Geology, and especially Quaternary Geology, has lost a zealous and able cultivator, and the Society a Member of great accomplishments and very versatile abilities. Continued illness prevented him from publishing the results of his labours; but his fossils, collected with the utmost care and accompanied by valuable notes, have enabled Dr. Falconer and Professor Heer to give an adequate account of the animals which lived upon the preglacial continent and of the vegetation which clothed its surface*.

Samuel William King, born September 20, 1821, was the eldest son of the late Rev. William Hutchinson King, formerly Vicar of Nuneaton. At an early age he showed a taste for scientific studies. While a mere boy, from fourteen to sixteen years old, he kept a journal in which astronomical observations and dissections of insects were noted down. Some of his papers were published at the time in the 'Zoologist.' As he grew older he turned his attention also to Archæology and Architecture. He entered at St. Catherine's College, Cambridge, and took the degree of B.A. in 1844, and that of M.A. in 1847. In 1849 he married Emma, daughter of the late John Fort, Esq., M.P., and in 1851 was presented to the Rectory of Saxlingham, Norfolk, where he devoted himself with unflagging energy to his parochial work, and to the study of the antiquities and natural history of the county.

He travelled much, note- and sketch-book in hand. In 1849 and 1850 he visited Switzerland, Italy, Sicily, the Grecian Archipelago, Constantinople, and Asia Minor. In 1855 he explored the little-known valleys between Monte Rosa and Mont Blanc; and subsequently published 'The Italian Valleys of the Pennine Alps,' a work that is of very high value, from the rare combination of literary ability with great powers of observation and artistic skill which it manifests. Subsequently he became a Fellow of the Society of Antiquaries and of the Royal Geographical Society. In 1855 he communicated to the Norfolk and Norwich Archæological Society a paper on the "Examination of an Ancient Cemetery at Hempnall," and in 1859 a second on a "Roman Kiln and Urns found at Hedenham."

On his return, in 1859, from his favourite Pennine valleys and the battle-fields of Solferino and Magenta, his attention was especially directed to the Norfolk Forest-bed by a visit to Cromer with Sir Charles Lyell, Dr. Hooker, and the Rev. John Gunn. From that time he devoted himself to the study of the preglacial beds of Norfolk, and to the accumulation of the fossils that now form the King Collection, which derives a peculiar value from the careful notes of the stratigraphical position of each specimen.

In 1860 he became a Fellow of the Geological Society. In 1864 he was so seriously affected by overwork that he was sent abroad by his medical advisers to seek the rest of mind which he could not obtain in England; but he merely exchanged one field of mental activity for another. On his return through France, after visiting Spain and Majorca, he reopened the famous Cave of Aurignac, and disco-

* See Lyell, 'Antiquity of Man,' pp. 214–217.

vered a large number of bones which proved that the cave was open in prehistoric times. A full statement of the bearing of this discovery upon the value of the evidence afforded by the cave, accompanied by the most careful plans and sections, would have been published, had not Mr. King's increasing illness forbidden work of any kind. After his return to England he gradually became worse, until in 1867 he resolved to winter in Algiers, and to give up his favourite pursuits and deeply cherished schemes of work. Thence he travelled to Switzerland, and, daily becoming weaker, he died on the 8th of July, 1868, at Pontresina, in the Engadine, in full possession of all his faculties.

One of Mr. King's last expressed wishes was that his collection, containing all Professor Heer's type specimens of preglacial vegetation, and a large number of Dr. Falconer's type-specimens of Mammals, should be presented to some museum where it might be used for the advancement of the science he loved so well. Accordingly it has found a resting-place in the Museum of Practical Geology in Jermyn Street.

Quaternary Geology has suffered additional losses among our Foreign Members in M. Boucher de Perthes and M. Morlot, whose names will be always honourably associated with that revival of scientific inquiry into the antiquity of man of which this generation has been witness.

M. Jacques Boucher de Crèvecœur de Perthes, who died in August last, was born in the year 1789, at the commencement of that great era of change which divides modern France from old France. He could hardly recollect the Terror; but the Directory, the Consulate, the Empire, the Restoration, the second Republic, and the second Empire, all had swept before him.

Possessed of an independent fortune, of considerable and varied powers and wide sympathies, M. Boucher de Perthes early resigned an official appointment in order to devote the long remainder of a healthy and vigorous life to travel, to literature, to archæology, and to science. His industry was exemplary, his enthusiasm boundless, his imagination fully equal to all demands made upon it. Hence it is no wonder that his fertile pen poured forth travels, political speculations, and a very readable novel—that he occupied himself with the past of man, and even with the future of woman. But he is most widely known by the great stimulus which his 'Antiquités Celtiques et Antédiluviennes,' published in 1849, gave to the study of the evidence of the antiquity of man which is afforded by the worked implements found imbedded in the same deposits with extinct animals.

The geologists of his own country treated M. Boucher de Perthes's work with indifference and neglect; and no doubt popular historians of science, judging after the event, will hereafter visit them with reprobation for their blindness and their prejudices. But just and critical students of the 'Antiquités' will, I think, be able completely to comprehend, and largely to justify, the course taken by the French geologists. Columbus discovered the new world; and great is his fame for that achievement, history, like some other great powers, always paying upon results: but those who will look carefully into the matter will find that most of his reasons for believing in the existence of the new land which he discovered were either insufficient or erroneous, and might well fail to carry conviction to the minds of the much-abused kings and ministers who so long withheld their help to his great enterprise.

And I venture to doubt whether, if any cautious person were now to read the 'Antiquités Celtiques,' he would rise from its perusal with the feeling that the author's case had been even approximately made out—whether, perhaps, he would not rather be prejudiced against it. Eminently generous, truthful, hearty, and enthusiastic, Boucher de Perthes paid for these virtues by a certain facility of belief, which is as terrible a drawback to scientific weight as it is advantageous in the struggle against neglect and adverse criticism when a man happens to have laid hold of a truth.

I say this much in justification of our *confrères* across the channel, and in vindication of caution and scientific logic, with which I, for one, prefer to err, rather than to be right in the company of haste and guesswork. Posterity, a somewhat short-sighted personage, who, as I have said, pays only upon results, will take no note of the protest, and will not only award to our Columbus all the credit which he deserves for being substantially in the right, but will probably abuse those of his contemporaries who were equally in the right for disbelieving him.

The death of M. A. Morlot, which took place at Berne, in February last, was announced at the last Anniversary. I borrow the substance of the following notice of his life from the "Matériaux" of M. G. de Mortillet.

M. Morlot commenced his career as a geologist, and greatly occupied himself with geology, in Austria. In Switzerland, where he subsequently took up his abode, he very successfully combined archæology with geology, and when he died was Conservator of the Archæological Museum of Berne. Although a Professor of Geology in Lausanne, he devoted himself to prehistoric studies, and greatly contributed to their progress by his investigations, his writings, and the public lectures which he was continually giving in one place or another.

The chief palæo-ethnological work of M. Morlot is entitled 'Études Géologico-Archéologiques en Danemark et en Suisse,' which was published at Lausanne in March 1860 in the 'Bulletin de la Société Vaudoise des Sciences Naturelles.' It is an excellent *résumé*, which has been of great use in spreading far and wide a knowledge of the important discoveries made in Denmark and Switzerland.

The discovery upon which M. Morlot laid most weight, is that of the "Cône de la Tinière," which he converted into a chronometer for measuring the duration of the different prehistoric epochs. M. Morlot's last production is a great work upon Mecklembourg.

James David Forbes, late Principal of the University of St. Andrews, in Scotland, was born in Edinburgh on the 28th of April, 1809. His mother died shortly after his birth, of consumption; and the boy's delicacy was such, that his father, Mr. William Forbes, of Pitsligo, thought it well to discourage rather than to stimulate his love for knowledge, mathematical studies being especially forbidden.

But nature was stronger than paternal solicitude; and natural genius made such good use of all available opportunities for study that in 1833, at the early age of 24, Mr. Forbes was appointed Professor of Natural Philosophy in the University of Edinburgh, an office the duties of which he performed with great distinction for twenty-six years, though in the latter part of that period impeded by failing health. In 1859 Professor Forbes was appointed Principal of the United Colleges of St. Salvador and St. Leonard in the University of St. Andrews, and held these offices until his lamented death on the 31st of December, 1868.

Principal Forbes attained high distinction as an original investigator in several branches of physics, while, to the general public, he was widely known and deservedly famed as the writer who had brought the grand and profoundly interesting aspects of the Alpine world before their minds with a power and distinctness which no one since the days of Saussure had approached, when the 'Travels in the Alps' were published.

My friend and colleague Mr. Geikie, F.R.S., has given so admirable an account of Principal Forbes's relation to geological science, that I venture to reproduce what he has said on this occasion:—

Principal Forbes was born in Edinburgh just twelve years after the death of the great Hutton, only seven years after the publication of the 'Illustrations of the Huttonian Theory;' and he was already a boy of ten when Playfair died. Many of his friends had been personally acquainted with these philosophers; and the memory of the fierce Plutonian and Neptunian war was still fresh in their minds when he began to give himself to scientific pursuits. These early influences are traceable all through his life. He was profoundly impressed with the originality and truth of the views propounded by Hutton and illustrated by Playfair. He speaks with enthusiasm of the "precious lessons" which one of his friends had drawn from the lips of Playfair and of Hall. I shall never cease to remember with gratitude that it was he who introduced me when a boy to the writings of these masters. He used to speak of Playfair's 'Illustrations of the Huttonian Theory' as one of the best books ever written upon the first principles of geological science.

Principal Forbes studied geology under Jameson, from whom he acquired a love for the mineralogical side of the science, and retained it to the last. Moreover his own predominant tendency towards physics tinged even his geological studies. Hence we find him rising, on the one hand, from a contemplation of the phenomena of glaciers to a philosophical investigation of the laws under which these phenomena occur—on the other, from the mere observation and collection of rocks and minerals to the natural philosophy of the operations by which they were produced.

The earliest of his geological writings which I have been able to trace is in the form of a short letter to Professor Jameson, on the occurrence of a large greenstone boulder in the Pentland Hills. It is dated from Colinton House, August 3rd, 1829, when its writer was a very little over twenty years of age. It gives an account of the position of the boulder, its composition, dimensions, and specific gravity. But the chief interest it possesses lies in the broad generalization which the young observer drew from the facts he had so carefully noted. The boulder lay upon the side of a small, steep ravine; and its position there was such as to lead him to regard the induction as undeniable, "that the excavation of the valley must have taken place subsequently to the deposition of this boulder." He remarks further that this inference as to the lateness of the erosion of valleys is forced upon us by many other instances which intimate the gradual degradation of the soil. Those who have watched the progress of geological discussion in recent years will see at how early a period our departed friend had acquired clear views upon this subject, and had based them upon the results of actual observation. This early paper is further interesting, inasmuch as it serves to indicate the special field of geology into which Forbes's natural instincts turned him, and in which he was destined in later years to reap so abundant a harvest. He had often read and treasured in his memory the eloquent passages in which Playfair, following in the path of Hutton, had expounded the erosion of valleys and the universal decay and waste of the continents. He saw that the happy suggestions and sagacious inferences of these philosophers ought to be regarded in the light rather of an outline of what remained to be discovered than as the epitome of a completed philosophy. Whatever related to the forces which work upon the surface of the earth and effect geological changes had a special charm for him. It was this tendency which led him to wander with more than a tourist's curiosity among the glaciers of Switzerland, which first suggested to him the idea of working out by accurate observation the real cause of glacier-motion, still, in his opinion, undiscovered, and which brought him back year after year to these great mountains, where he toiled with a devotion that told at last upon his physical frame. He was the first to determine by careful measurements the amount and variations of glacier-motion. Comparing that motion to the flow of a river, he propounded the theory that "a glacier is an imperfect fluid or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts." The observations and journeys which led him to this deduction are detailed in his 'Travels in the Alps,' a work in which, as in the 'Voyages dans les Alpes' of De Saussure, which he took as his model, description of scenery and narrative of adventure are happily blended with scientific observation and reasoning. The vexed question of the mechanical cause of the motion of glaciers is hardly a geological problem. I would rather refer to the abundant materials collected by Forbes in this work for the elucidation of the geological functions of glaciers. The existing operations of the ice, in scoring and polishing rocks, in transporting huge blocks of stone, and in depositing vast mounds of rubbish, are illustrated by him from many an Alpine valley. Recalling the original observations of Playfair, he points out how clear is the evidence for the former wide extension of the glaciers of Switzerland. In short, his eye seems ever to have been upon the watch for every phenomenon bearing upon the mutations of the existing surface of the land.

The lessons which he had thus laboriously learned among the living ice-rivers of the Alps bore fruit when he came again to wander among the more mountainous regions of his own country. In the year 1840 Agassiz had made the startling announcement that the British islands had once been deeply buried under a vast mantle of snow and ice, and that the traces of its seaward motion were yet fresh and clear upon the sides of many valleys among the uplands. Following up the observations of the Swiss naturalist, Buckland and Lyell had pointed out the former existence of glaciers in the Highlands and other parts of the country. When, however, we look back upon the early discussion of this subject, we are forced to admit that conclusions were often based upon very hasty and imperfect observations. In particular, glacier moraines were often recognized in places where no geologist would now be able to find them. Much as Forbes knew of the geological effects of ice, his natural caution kept him from taking part in this discussion for a time, until he was able to produce more accurately determined data than had, in many cases at least, been available. In the year 1845 he visited the Isle of Skye; and his eye, already trained to recognize the traces of vanished glaciers in Switzerland, was at once struck by the identity of the forms assumed by the rocks at Loch Scavaig with the *roches moutonnées* of the Alps. Further investigation led him to obtain complete demonstration of the former presence of a group of glaciers descending from the rugged scarps of the Cuchullin Hills. He walked over mountain and glen, filling in a rough sketch map of the glacier valleys as he went along, and in December of the same year he read a narrative of his observations to the Royal Society of Edinburgh. This was the most detailed and satisfactory account which had yet been given of the proofs that the Highlands of Britain once nourished groups of glaciers.

In the year 1851 Professor Forbes undertook a journey to Norway, partly to make observations of the great solar eclipse, and partly drawn by his love of physical geography, and notably of glaciers. It was his design to compare the phenomena of glaciers in Northern Europe with those already so familiar to him in Switzerland. This he has done in a masterly way. His pages contain, in a clear and succinct form, the sum of all that was known at the time regarding the snow-line and the existing glaciers of Norway. I have myself gone over much of the ground he has described, and can bear witness to the accuracy of his sketches, alike of pencil and of pen. His two chapters on the physical geography of Norway have always appeared to me to be a masterpiece of careful yet rapid observation, broad generalization, and clear description.

But though the tendency of his researches in geology was mainly towards the investigation of the phenomena connected with changes in the outline of the surface, he did not neglect the study of minerals and rocks, in which he had been trained under Jameson. Previously to 1836, with the view of learning more of the history of ancient geological upheavals, he had examined "the trap rocks of our own island, the ophites of the Pyrenees, and the serpentines of Anglesea and the Lizard—the porphyries of Northern Italy—the granite veins of Mount's Bay and Glen Tilt—the ancient volcanoes of Auvergne, the Eifel, the Siebengebirge, and of Rome—and the modern volcano of Vesuvius." In December 1835 he gave to the Royal Society of Edinburgh a narrative of his researches in central France, dwelling more especially on the analogies between the volcanic rocks of that district and the trappean masses of his own country. Throughout his narratives of foreign travel, also, we everywhere meet with indications that, though busied with what had become his own more special branch of the science, he remained no indifferent observer of the rocks among which his journeys led him. He retained his fondness for mineralogy to the end. When I last saw him at St. Andrews he showed me a collection of veined agates which he had accumulated in the course of years, and with which he used often to beguile a little leisure in trying to speculate upon the manner in which the concentric siliceous coatings might have been formed.

In concluding this sketch of the late Principal's geological labours, I must not forget that some of his researches, though in themselves dealing with more or less distinctively physical questions, had often important geological bearings. Such were some of his meteorological investigations, and his carefully conducted experiments upon the temperature of the earth at different depths and in different soils near Edinburgh. These experiments were, I believe, the first made in this country, with any degree of precision, to determine the rate at which the temperature of the surface is conducted downwards, and the variations due to differences in the nature of the material through which the heat is transmitted.

Sir David Brewster was born at Jedburgh in December 1781, and had thus attained the advanced age of more than eighty-six years when he died in February of last year. During this long life his scientific activity was incessant, and the stream of his original papers, some 300 in number, flowed on without a check.

Nor did this singular fertility by any means exhaust Sir David Brewster's energies. He wrote in the Reviews frequently and well; he edited the 'Edinburgh Encyclopædia,' and shared in editing the 'Edinburgh Philosophical Journal,' the 'Edinburgh Journal of Science,' and the 'Philosophical Magazine.' He founded the Scottish Society of Arts, and helped to found the British Association; he was Principal of St. Andrews, and afterwards of Edinburgh University; he was long Secretary of the Royal Society of Edinburgh, and he died the President of that learned body.

With all these occupations Sir David found time to invent one of the prettiest of toys, the Kaleidoscope; to write one of the most charming of popular scientific treatises, the 'Letters on Natural Magic;' and to enter into a considerable number of controversies, in which he displayed such a capacity for the outpouring of copious wrath, that his adversaries must have found it difficult to believe that he had anything else to do but to assail them. But this marvellous energy was never directed to geological problems. Sir David was familiar with minerals, but he regarded them with the eye of a student of optics; and even his discovery of the cavities in crystals and of their contents did not cause him to diverge from his favourite line of study. Once, indeed, he plunged into cosmology; but 'More Worlds than One' hardly added to the renown which he had justly obtained as an unwearied observer and accumulator of facts in optics.

Dr. Eugene Francfort, Commendatore of the Order of St. Maurice and St. Lazarus, whose sudden decease took place at Pallanza, on the 22nd September 1868, had for some years directed the application of English capital to the working of numerous mines near the Lago Maggiore and in the Val Anzasca. He had in early life worked at chemistry and geology in the United States, and when established in Italy exhibited such enthusiasm in the pursuit of mineralogy as secured him the friendship of many scientific men of eminence in that country. His liberality, a rare virtue among collectors, will not soon be forgotten by the friends who lament his untimely end.

Dr. Henry Porter was born July 13th, 1832, at Peterborough, in which town his father practised as a surgeon. He received his primary education at the Hereford school under the Rev. Henry Manton, and while yet a school-boy, his interest in Geology having been awakened by the perusal of one of Dr. Mantell's works, he became an enthusiastic collector and student of fossils. On leaving school he spent three years in his father's surgery, and then passed to Queen's College, Birmingham, where he greatly distinguished himself, obtaining a scholarship, two gold medals, and other honours, and becoming at the end of his three years' course of study Warnford's Prize-man. On leaving Birmingham, he continued his studies in London and Paris.

Returning to his native town, Dr. Porter entered on the practice of his profession, devoting his leisure hours to the study of the geology of the district and the formation of a collection of fossils. In 1861 he became a Fellow of this Society, and in the same year published his 'Geology of Peterborough.' This unpretentious but useful little work is an attempt to give in popular language such a sketch of the Geology of a limited district as may be calculated to awaken in residents an interest in our science, and, by furnishing the necessary basis of information, lead the way to further researches. In 1863 Dr. Porter contributed a paper to this Society "On the occurrence of large quantities of Fossil Wood in the Oxford Clay, near

Peterborough;" he likewise, at different times, communicated various memoirs on professional subjects to the Medical Society.

It must ever be a subject of regret to geologists, as it was to the last to himself, that during the latter years of his life our esteemed associate was prevented by his feeble state of health, combined with his numerous professional and other engagements, from devoting much time to scientific pursuits. His death, which took place at the early age of thirty-six, was hastened by an accident, a fall from his horse, resulting in paralysis, which terminated fatally, August 11, 1868.

Dr. Porter was an assiduous labourer for the benefit of his native town, in which the well-known excellencies of his character gained for him universal respect and goodwill. His brilliant and agreeable qualities were never more conspicuous than when he played the part of a host; and no one could be better qualified for the authorship of the half-playful, half-serious little work, 'Cups and their Customs,' which was written in 1863, in conjunction with another Fellow of this Society, also deceased, Mr. George E. Roberts. The results of the geological labours of Dr. Porter are not be estimated by his published writings alone; his extensive and valuable collection was always open to investigators of the geology of the district; and all who availed themselves of this privilege will remember with sadness his modesty and zeal not less than his geniality and hospitality.

The Rev. Joseph G. Cumming, M.A., F.G.S., Vicar of St. John's, Bethnal Green, was the son of the late Joseph Nottrall Cumming, Esq., of Matlock, where he was born on the 15th February, 1812. Mr. Cumming was educated at Oakham Grammar School; and an old Oakham school-fellow has written of him:—"He was the very opposite of 'a pickle.' I do not think I ever saw such a grave earnest boy, cheerful, indeed, and eminently good-natured. He was, perhaps, about 14 years old when I first knew him, and we became close companions for at least two years afterwards, when I quitted the school. I do not remember that I ever saw him with a cricket-bat or fishing-rod; but he was very fond of talking of the wonders of Derbyshire, and presented me with some fossils. He was fond of wrestling, and we frequently walked to a quiet field some half mile from the town, and tugged at each others collars for hours on pretty equal terms."

Mr. Cumming gained exhibitions at Oakham, and proceeded to Emmanuel College, Cambridge, where he (Senior Opt.* 1834) was ordained in 1835, and took the curacy of his uncle, the Rev. James Cumming, Professor of Chemistry at Cambridge, and Rector of North Nuneton, Norfolk. In 1838 he was appointed Classical Master of the West Riding Proprietary School, and in 1841 Vice Principal of King William's College in the Isle of Man, where he acquired an interest in the history and antiquities of the island that never deserted him, and he contributed very largely to their illustration. Mr. Cumming remained about fifteen years in the Isle of Man, and removed on his appointment to the Mastership of King Edward's

* See Cambridge Calendar.

Grammar School, Lichfield. In 1858 he was appointed Warden and Professor of Classical Literature and Geology in Queen's College, Birmingham. In 1862 he was presented by the Lord Chancellor to the Rectory of Mellis, Suffolk, which he exchanged in 1867 for the Vicarage of St. John's, Bethnal Green. On the 21st September, 1868 he suddenly died whilst residing in the midst of his family circle; his removal to London, and his untiring exertions among the poor of Bethnal Green, probably, materially abridged his life. He was emphatically a hard worker both as clergyman and man of science.

Mr. Cumming was married in 1836, to Agnes, youngest daughter of J. R. Peckham, Esq., who survives him with a family of four sons and two daughters.

Mr. Cumming was the author of a 'History of the Isle of Man,' and of papers on "The Geology of the Isle of Man," "The Tertiaries of the Moray Frith," "The Geology of the Calf of Man," and "The Superior Limits of the Glacial Deposits in the Isle of Man," which are published in our Journal. He became a Fellow of the Geological Society in 1846.

"A great reform in geological speculation seems now to have become necessary."

"It is quite certain that a great mistake has been made,—that British popular geology at the present time is in direct opposition to the principles of Natural Philosophy"*.

In reviewing the course of geological thought during the past year, for the purpose of discovering those matters to which I might most fitly direct your attention in the Address which it now becomes my duty to deliver from the Presidential Chair, the two somewhat alarming sentences which I have just read, and which occur in an able and interesting essay by an eminent natural philosopher, rose into such prominence before my mind that they eclipsed everything else.

It surely is a matter of paramount importance for the British geologists (some of them very popular geologists too) here in solemn annual session assembled, to inquire whether the severe judgment thus passed upon them by so high an authority as Sir William Thomson is one to which they must plead guilty *sans phrase,* or whether they are prepared to say "not guilty," and appeal for a reversal of the sentence to that higher court of educated scientific opinion to which we are all amenable.

As your attorney-general for the time being, I thought I could not do better than get up the case with a view of advising you. It is true that the charges brought forward by the other side involve the consideration of matters quite foreign to the pursuits with which I am ordinarily occupied; but in that respect I am only in the position which is, nine times out of ten, occupied by counsel, who nevertheless contrive to gain their causes, mainly by force of mother-

* On Geological Time. By Sir W. Thomson, LL.D. Transactions of the Geological Society of Glasgow, vol. iii.

wit and common sense, aided by some training in other intellectual exercises.

Nerved by such precedents, I proceed to put my pleading before you.

And the first question with which I propose to deal is, What is it to which Sir W. Thomson refers when he speaks of "geological speculation" and "British popular geology"?

I find three more or less contradictory systems of geological thought, each of which might fairly enough claim these appellations, standing side by side in Britain. I shall call one of them CATASTROPHISM, another UNIFORMITARIANISM, the third EVOLUTIONISM; and I shall try briefly to sketch the characters of each, that you may say whether the classification is or is not exhaustive.

By CATASTROPHISM I mean any form of geological speculation which, in order to account for the phenomena of geology, supposes the operation of forces different in their nature, or immeasurably different in power, from those which we at present see in action in the universe.

The Mosaic cosmogony is, in this sense, catastrophic, because it assumes the operation of extra-natural power. The doctrine of violent upheavals, *débâcles*, and cataclysms in general is catastrophic, so far as it assumes that these were brought about by causes which have now no parallel. There was a time when catastrophism might preeminently have claimed the title of "British popular geology;" and assuredly it has yet many adherents, and reckons among its supporters some of the most honoured members of this Society.

By UNIFORMITARIANISM I mean preeminently the teaching of Hutton and of Lyell.

That great, though incomplete work, 'The Theory of the Earth,' seems to me to be one of the most remarkable contributions to geology which is recorded in the annals of the science. So far as the not-living world is concerned, uniformitarianism lies there, not only in germ, but in blossom and fruit.

If one asks how it is that Hutton was led to entertain views so far in advance of those prevalent in his time in some respects, while in others they seem almost curiously limited, the answer appears to me to be plain.

Hutton was in advance of the geological speculation of his time, because, in the first place, he had amassed a vast store of knowledge of the facts of geology, gathered by personal observation in travels of considerable extent, and because, in the second place, he was thoroughly trained in the physical and chemical science of his day, and thus possessed, as much as any one in his time could possess it, the knowledge which was requisite for the just interpretation of geological phenomena, and the habit of thought which fits a man for scientific inquiry.

It is to this thorough scientific training that I ascribe Hutton's steady and persistent refusal to look to other causes than those now in operation for the explanation of geological phenomena.

Thus he writes:—"I do not pretend, as he [M. de Luc] does in his theory, to describe the beginning of things. I take things such as I find them at present; and from these I reason with regard to that which must have been"*.

And again:—"A theory of the earth, which has for object truth, can have no retrospect to that which had preceded the present order of the world; for this order alone is what we have to reason upon; and to reason without data is nothing but delusion. A theory, therefore, which is limited to the actual constitution of this earth cannot be allowed to proceed one step beyond the present order of things"†.

And so clear is he that no causes besides such as are now in operation are needed to account for the character and disposition of the components of the crust of the earth, that he says, broadly and boldly:—". . . . . There is no part of the earth which has not had the same origin, so far as this consists in that earth being collected at the bottom of the sea, and afterwards produced, as land, along with masses of melted substances, by the operation of mineral causes"‡.

But other influences were at work upon Hutton beside those of a mind logical by nature, and scientific by sound training; and the peculiar turn which his speculations took seems to me to be unintelligible unless these be taken into account. The arguments of the French astronomers and mathematicians, which, at the end of the last century, were held to demonstrate the existence of a compensating arrangement among the celestial bodies, whereby all perturbations eventually reduced themselves to oscillations on each side of a mean position, and the stability of the solar system was secured, had evidently taken strong hold of Hutton's mind.

In those oddly constructed periods which seem to have prejudiced many persons against reading his works, but which are full of that peculiar, if unattractive, eloquence which flows from mastery of the subject, Hutton says:—

"We have now got to the end of our reasoning; we have no data further to conclude immediately from that which actually is. But we have got enough; we have the satisfaction to find, that in nature there is wisdom, system, and consistency. For having, in the natural history of this earth, seen a succession of worlds, we may from this conclude that there is a system in nature; in like manner as, from seeing revolutions of the planets, it is concluded, that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in the system of nature, it is in vain to look for anything higher in the origin of the earth. The result, therefore, of this physical inquiry is, that we find no vestige of a beginning,—no prospect of an end"§.

Yet another influence worked strongly upon Hutton. Like most philosophers of his age, he coquetted with those final causes which have been named barren virgins, but which might be more fitly termed the *hetairæ* of philosophy, so constantly have they led men

* The Theory of the Earth, vol. i. p. 173, note. † Ib. p. 281.
‡ Ib. p. 371. § Ib. p. 200.

astray. The final cause of the existence of the world is, for Hutton, the production of life and intelligence.

"We have now considered the globe of this earth as a machine, constructed upon chemical as well as mechanical principles, by which its different parts are all adapted, in form, in quality, and in quantity, to a certain end; an end attained with certainty or success; and an end from which we may perceive wisdom, in contemplating the means employed.

"But is this world to be considered thus merely as a machine, to last no longer than its parts retain their present position, their proper forms and qualities? Or may it not be also considered as an organized body? such as has a constitution in which the necessary decay of the machine is naturally repaired, in the exertion of those productive powers by which it had been formed.

"This is the view in which we are now to examine the globe; to see if there be, in the constitution of this world, a reproductive operation, by which a ruined constitution may be again repaired, and a duration or stability thus procured to the machine, considered as a world sustaining plants and animals"*.

Kirwan and the other Philistines of the day accused Hutton of declaring that his theory implied that the world never had a beginning, and never differed in condition from its present state. Nothing could be more grossly unjust, as he expressly guards himself against any such conclusion in the following terms:—

"But in thus tracing back the natural operations which have succeeded each other, and mark to us the course of time past, we come to a period in which we cannot see any farther. This, however, is not the beginning of the operations which proceed in time and according to the wise œconomy of this world; nor is it the establishing of that which, in the course of time, had no beginning; it is only the limit of our retrospective view of those operations which have come to pass in time, and have been conducted by supreme intelligence"†.

I have spoken of Uniformitarianism as the doctrine of Hutton and of Lyell. If I have quoted the older writer rather than the newer, it is because his works are little known, and his claims on our veneration too frequently forgotten, not because I desire to dim the fame of his eminent successor. Few of the present generation of geologists have read Playfair's 'Illustrations,' fewer still the original 'Theory of the Earth;' the more is the pity; but which of us has not thumbed every page of the 'Principles of Geology'? I think that he who writes fairly the history of his own progress in geological thought will not be able to separate his debt to Hutton from his obligations to Lyell; and the history of the progress of individual geologists is the history of geology.

No one can doubt that the influence of uniformitarian views has been enormous, and, in the main, most beneficial and favourable to the progress of sound geology.

Nor can it be questioned that uniformitarianism has even a stronger

* Ib. pp. 16, 17 † Ib. p. 223.

title than catastrophism to call itself the geological speculation of Britain, or, if you will, British popular geology. For it is eminently a British doctrine, and has even now made comparatively little progress on the continent of Europe. Nevertheless it seems to me to be open to serious criticism upon one of its aspects.

I have shown how unjust was the insinuation that Hutton denied a beginning to the world. But it would not be unjust to say that he persistently, in practice, shut his eyes to the existence of that prior and different state of things which in theory he admitted; and in this aversion to look beyond the veil of stratified rocks Lyell follows him.

Hutton and Lyell alike agree in their indisposition to carry their speculations a step beyond the period recorded in the most ancient strata now open to observation in the crust of the earth. This is, for Hutton, "the point in which we cannot see any farther;" while Lyell tells us,—

"The astronomer may find good reasons for ascribing the earth's form to the original fluidity of the mass in times long antecedent to the first introduction of living beings into the planet; but the geologist must be content to regard the earliest monuments which it is his task to interpret, as belonging to a period when the crust had already acquired great solidity and thickness, probably as great as it now possesses, and when volcanic rocks, not essentially differing from those now produced, were formed from time to time, the intensity of volcanic heat being neither greater nor less than it is now"*.

And again, "As geologists, we learn that it is not only the present condition of the globe which has been suited to the accommodation of myriads of living creatures, but that many former states also have been adapted to the organization and habits of prior races of beings. The disposition of the seas, continents and islands, and the climates have varied; the species likewise have been changed; and yet they have all been so modelled, on types analogous to those of existing plants and animals, as to indicate, throughout, a perfect harmony of design and unity of purpose. To assume that the evidence of the beginning, or end, of so vast a scheme lies within the reach of our philosophical inquiries, or even of our speculations, appears to be inconsistent with a just estimate of the relations which subsist between the finite powers of man and the attributes of an infinite and eternal Being"†.

The limitations implied in these passages appear to me to constitute the weakness and the logical defect of uniformitarianism. No one will impute blame to Hutton that, in face of the imperfect condition, in his day, of those physical sciences which furnish the keys to the riddles of geology, he should have thought it practical wisdom to limit his theory to an attempt to account for "the present order of things"; but I am at a loss to comprehend why, for all time, the geologist must be content to regard the oldest fossiliferous rocks as the *ultima Thule* of his science, or what there is inconsistent with the relations between the finite and the infinite mind in the assump-

* Principles of Geology, vol. ii. p. 211. † Ib. p. 613.

tion that we may discern somewhat of the beginning, or of the end, of this speck in space we call our earth. The finite mind is certainly competent to trace out the development of the fowl within the egg; and I know not on what ground it should find more difficulty in unravelling the complexities of the development of the earth. In fact, as Kant has well remarked*, the cosmical process is really simpler than the biological.

This attempt to limit at a particular point the progress of inductive and deductive reasoning from the things which are to those which were—this faithlessness to its own logic, seems to me to have cost Uniformitarianism the place, as the permanent form of geological speculation, which it might otherwise have held.

It remains that I should place before you what I understand to be the third phase of geological speculation—namely Evolutionism.

I shall not make what I have to say on this head clear unless I diverge, or seem to diverge, for a while from the direct path of my discourse, so far as to explain what I take to be the scope of geology itself. I conceive geology to be the history of the earth in precisely the same sense as biology is the history of living beings; and I trust you will not think that I am overpowered by the influence of a dominant pursuit if I say that I trace a close analogy between these two histories.

If I study a living being, under what heads does the knowledge I obtain fall? I can learn its structure, or what we call its Anatomy; and its Development, or the series of changes which it passes through to acquire its complete structure. Then I find that the living being has certain powers resulting from its own activities, and the interaction of these with the activities of other things—the knowledge of which is Physiology. Beyond this the living being has a position in space and time, which is its Distribution. All these form the body of ascertainable facts which constitute the *status quo* of the living creature. But these facts have their causes; and the ascertainment of these causes is the doctrine of Ætiology.

If we consider what is knowable about the earth, we shall find that such earth-knowledge—if I may so translate the word geology—falls into the same categories.

What is termed stratigraphical geology is neither more nor less than the anatomy of the earth; and the history of the succession of the formations is the history of a succession of such anatomies, or corresponds with development, as distinct from generation.

The internal heat of the earth, the elevation and depression of its crust, its belchings forth of vapours, ashes, and lava are its activities in as strict a sense, as are warmth and the movements and products of respiration the activities of an animal. The phenomena of

* "Man darf es sich also nicht befremden lassen, wenn ich mich unterstehe zu sagen, dass eher die Bildung aller Himmelskörper, die Ursache ihrer Bewegungen, kurz der Ursprung der ganzen gegenwärtigen Verfassung des Weltbaues werden können eingesehen werden, ehe die Erzeugung eines einzigen Krauts oder einer Raupe aus mechanischen Gründen, deutlich und vollständig kund werden wird."—Kant's 'Sämmtliche Werke,' Bd. I. p. 220.

the seasons, of the trade winds, of the Gulf-stream are as much the results of the reaction between these inner activities and outward forces, as are the budding of the leaves in spring and their falling in autumn the effects of the interaction between the organization of a plant and the solar light and heat. And, as the study of the activities of the living being is called its physiology, so are these phenomena the subject-matter of an analogous telluric physiology, to which we sometimes give the name of meteorology, sometimes that of physical geography, sometimes that of geology. Again, the earth has a place in space and in time, and relations to other bodies in both these respects, which constitute its distribution. This subject is usually left to the astronomer; but a knowledge of its broad outlines seems to me to be an essential constituent of the stock of geological ideas.

All that can be ascertained concerning the structure, succession of conditions, actions, and position in space, of the earth is the matter of fact of its natural history. But, as in biology, there remains the matter of reasoning from these facts to their causes, which is just as much science as the other, and indeed more; and this constitutes geological ætiology.

Having regard to this general scheme of geological knowledge and thought, it is obvious that geological speculation may be, so to speak, anatomical and developmental speculation, so far as it relates to points of stratigraphical arrangement which are out of reach of direct observation; or it may be physiological speculation, so far as it relates to undetermined problems relative to the activities of the earth; or it may be distributional speculation, if it deals with modifications of the earth's place in space; or, finally, it will be ætiological speculation, if it attempts to deduce the history of the world, as a whole, from the known properties of the matter of the earth in the conditions in which the earth has been placed.

For the purposes of the present discourse I may take this last to be what is meant by 'geological speculation.'

Now uniformitarianism, as we have seen, tends to ignore geological speculation in this sense altogether. The one point the catastrophists and the uniformitarians agreed upon when this Society was founded, was to ignore it. And you will find, if you look back into our records, that our revered fathers in geology plumed themselves a good deal upon the practical sense and wisdom of this proceeding. As a temporary measure, I do not presume to challenge its wisdom; but in all organized bodies temporary changes are apt to produce permanent effects; and as time has slipped by, altering all the conditions which may have made such mortification of the scientific flesh desirable, I think the effect of the stream of cold water which has steadily flowed over geological speculation within these walls, has been of doubtful beneficence.

The sort of geological speculation to which I am now referring (geological ætiology, in short) was created as a science by that famous philosopher Immanuel Kant, when, in 1755, he wrote his 'General Natural History and Theory of the Celestial Bodies; or an attempt to account for the constitution and the mechanical origin of the universe upon Newtonian principles'*.

In this very remarkable, but seemingly little-known treatise †, Kant expounds a complete cosmogony, in the shape of a theory of the causes which have led to the development of the universe from diffused atoms of matter endowed with simple attractive and repulsive forces.

"Give me matter," says Kant, "and I will build the world;" and he proceeds to deduce from the simple data from which he starts, a doctrine in all essential respects similar to the well-known "Nebular Hypothesis" of Laplace ‡. He accounts for the relation of the masses and the densities of the planets to their distances from the sun, for the eccentricities of their orbits, for their rotations, for their satellites, for the general agreement in the direction of rotation among the celestial bodies, for Saturn's ring, and for the zodiacal light. He finds in each system of worlds indications that the attractive force of the central mass will eventually destroy its organization by concentrating upon itself the matter of the whole system; but, as the result of this concentration, he argues for the development of an amount of heat which will dissipate the mass once more into a molecular chaos such as that in which it began.

Kant pictures to himself the universe as once an infinite expansion of formless and diffused matter. At one point of this he supposes a single centre of attraction set up, and by strict deductions from admitted dynamical principles shows how this must result in the development of a prodigious central body surrounded by systems of solar and planetary worlds in all stages of development. In vivid language he depicts the great world-maelstrom widening the margins of its prodigious eddy in the slow progress of millions of ages, gradually reclaiming more and more of the molecular waste, and converting chaos into cosmos. But what is gained at the margin is lost in the centre; the attractions of the central systems bring their constituents together, which then by the heat evolved are converted once more into molecular chaos. Thus the worlds that are, lie between the ruins of the worlds that have been and the chaotic materials of the worlds that shall be; and in spite of all waste and destruction Cosmos is extending his borders at the expense of Chaos.

Kant's further application of his views to the earth itself is to be found in his 'Treatise on Physical Geography'§ (a term under which the then unknown science of geology was included), a subject which he had studied with very great care and on which he lectured for many years. The fourth section of the first part of this Treatise is called "History of the great changes which the earth has formerly

* Grant ('History of Physical Astronomy,' p. 574) makes but the briefest reference to Kant.

† "Allgemeine Naturgeschichte und Theorie des Himmels; oder Versuch von der Verfassung und dem mechanischen Ursprunge des ganzen Weltgebäudes nach Newton'schen Grundsätzen abgehandelt."—Kant's 'Sämmtliche Werke,' Bd. i. p. 207.

‡ Système du Monde, tom. ii. chap. 6.

§ Kant's 'Sämmtliche Werke,' Bd. viii. p. 145.

undergone and is still undergoing," and is in fact a brief and pregnant essay upon the principles of geology. Kant gives an account first "of the gradual changes which are now taking place" under the heads of such as are caused by earthquakes, such as are brought about by rain and rivers, such as are effected by the sea, such as are produced by winds and frost, and, finally, such as result from the operations of man.

The second part is devoted to the "Memorials of the changes which the earth has undergone in remote antiquity." These are enumerated as:—A. Proofs that the sea formerly covered the whole earth. B. Proofs that the sea has often been changed into dry land and then again into sea. C. A discussion of the various theories of the earth put forward by Scheuchzer, Moro, Bonnet, Woodward, White, Leibnitz, Linnæus, and Buffon.

The third part contains an "Attempt to give a sound explanation of the ancient history of the earth."

I suppose that it would be very easy to pick holes in the details of Kant's speculations, whether cosmological or specially telluric in their application. But, for all that, he seems to me to have been the first person to frame a complete system of geological speculation by founding the doctrine of evolution.

With as much truth as Hutton, Kant could say, "I take things just as I find them at present, and from these I reason with regard to that which must have been." Like Hutton, he is never tired of pointing out that "in nature there is wisdom, system, and constancy." And as in these great principles, so in believing that the cosmos has a reproductive operation "by which a ruined constitution may be repaired" he forestalls Hutton: while, on the other hand, Kant is true to science. He knows no bounds to geological speculation but those of the intellect. He reasons back to a beginning of the present state of things; he admits the possibility of an end.

I have said that the three schools of geological speculation which I have termed Catastrophism, Uniformitarianism, and Evolutionism are commonly supposed to be antagonistic to one another; and I presume it will have become obvious that, in my belief, the last is destined to swallow up the other two. But it is proper to remark that each of the latter has kept alive the tradition of precious truths.

Catastrophism has insisted upon the existence of a practically unlimited bank of force, on which the theorist might draw; and it has cherished the idea of the development of the earth from a state in which its form, and the forces which it exerted, were very different from those we now know. That such difference of form and power once existed is a necessary part of the doctrine of evolution.

Uniformitarianism, on the other hand, has with equal justice insisted upon a practically unlimited bank of time, ready to discount any quantity of hypothetical paper. It has kept before our eyes the power of the infinitely little, time being granted, and has compelled us to exhaust known causes before flying to the unknown.

To my mind there appears to be no sort of necessary theoretical antagonism between Catastrophism and Uniformitarianism. On the contrary, it is very conceivable that catastrophes may be part and parcel of uniformity. Let me illustrate my case by analogy. The working of a clock is a model of uniform action; good time-keeping means uniformity of action. But the striking of the clock is essentially a catastrophe; the hammer might be made to blow up a barrel of gunpowder, or turn on a deluge of water; and, by proper arrangement, the clock, instead of marking the hours, might strike at all sorts of irregular intervals, never twice alike in the intervals, force, or number of its blows. Nevertheless all these irregular and apparently lawless catastrophes would be the result of an absolutely uniformitarian action; and we might have two schools of clock-theorists, one studying the hammer and the other the pendulum.

Still less is there any necessary antagonism between either of these doctrines and that of Evolution, which embraces all that is sound in both Catastrophism and Uniformitarianism, while it rejects the arbitrary assumptions of the one and the, as arbitrary, limitations of the other. Nor is the value of the doctrine of Evolution to the philosophic thinker diminished by the fact that it applies the same method to the living and the not-living world, and embraces in one stupendous analogy the growth of a solar system from molecular chaos, the shaping of the earth from the nebulous cubhood of its youth, through innumerable changes and immeasurable ages, to its present form, and the development of a living being from the shapeless mass of protoplasm we term a germ.

I do not know whether Evolutionism can claim that amount of currency which would entitle it to be called British popular geology; but, more or less vaguely, it is assuredly present in the minds of most geologists.

Such being the three phases of geological speculation, we are now in a position to inquire which of these it is that Sir William Thomson calls upon us to reform in the passages which I have cited.

It is obviously Uniformitarianism which the distinguished physicist takes to be the representative of geological speculation in general. And thus a first issue is raised, inasmuch as many persons (and those not the least thoughtful among the younger geologists) do not accept strict Uniformitarianism as the final form of geological speculation. We should say, if Hutton and Playfair declare the course of the world to have been always the same, point out the fallacy by all means, but in so doing do not imagine that you are proving modern geology to be in opposition to natural philosophy. I do not suppose that, at the present day, any geologist would be found to maintain absolute Uniformitarianism, to deny that the rapidity of the rotation of the earth *may* be diminishing, that the sun *may* be waxing dim, or that the earth itself *may* be cooling. Most of us, I suspect, are Gallios, "who care for none of these things," being of opinion that, true or fictitious, they have made no practical difference to the earth, during the period of which a record is preserved in stratified deposits.

The accusation that we have been running counter to the *principles* of natural philosophy, therefore, is devoid of foundation. The only question which can arise is whether we have, or have not, been tacitly making assumptions which are in opposition to certain conclusions which may be drawn from those principles. And this question subdivides itself into two:—the first, are we really contravening such conclusions? the second, if we are, are those conclusions so firmly based that we may not contravene them? I reply in the negative to both these questions, and I will give you my reasons for so doing. Sir William Thomson believes that he is able to prove by physical reasonings, "that the existing state of things on the earth, life on the earth—all geological history showing continuity of life—must be limited within some such period of time as one hundred million years" (*loc. cit.* p. 25).

The first inquiry which arises plainly is, has it ever been denied that this period *may* be enough for the purposes of geology?

The discussion of this question is greatly embarrassed by the vagueness with which the assumed limit is, I will not say defined, but indicated,—"some such period of past time as one hundred million years." Now does this mean that it may have been two, or three, or four hundred million years? Because this really makes all the difference*.

I presume that 100,000 feet may be taken as a full allowance for the total thickness of stratified rocks containing traces of life; 100,000 divided by 100,000,000=0·001. Consequently, the deposit of 100,000 feet of stratified rock in 100,000,000 years means that the deposit has taken place at the rate of $\frac{1}{1000}$ of a foot, or, say, $\frac{1}{83}$ of an inch, per annum.

Well, I do not know that any one is prepared to maintain that, even making all needful allowances, the stratified rocks may not have been formed, on the average, at the rate of $\frac{1}{83}$ of an inch per annum. I suppose that if such could be shown to be the limit of world-growth, we could put up with the allowance without feeling that our speculations had undergone any revolution. And perhaps, after all, the qualifying phrase "some such period" may not necessitate the assumption of more than $\frac{1}{166}$, or $\frac{1}{249}$, or $\frac{1}{332}$ of an inch of deposit per year, which, of course, would give us still more ease and comfort.

But it may be said that it is biology, and not geology, which asks for so much time—that the succession of life demands vast intervals; but this appears to me to be reasoning in a circle. Biology takes her time from geology. The only reason we have for believing in the slow rate of the change in living forms is the fact that they persist through a series of deposits which geology informs us have taken a long while to make. If the geological clock is wrong, all the naturalist will have to do is to modify his notions of the rapidity of change accordingly. And I venture to point out that, when we are told that the

* Sir William Thomson implies (*loc. cit.* p. 16) that the precise time is of no consequence, "the principle is the same"; but as the principle is admitted, the whole discussion turns on its practical results.

limitation of the period during which living beings have inhabited this planet to one, two, or three hundred million years requires a complete revolution in geological speculation, the *onus probandi* rests on the maker of the assertion, who brings forward not a shadow of evidence in its support.

Thus, if we accept the limitation of time placed before us by Sir W. Thomson, it is not obvious, on the face of the matter, that we shall have to alter, or reform, our ways in any appreciable degree; and we may therefore proceed with much calmness, and, indeed, much indifference to the result, to inquire whether that limitation is justified by the arguments employed in its support.

These arguments are three in number:—

I. The first is based upon the undoubted fact that the tides tend to retard the rate of the earth's rotation upon its axis. That this must be so is obvious, if one considers roughly that the tides result from the pull which the sun and the moon exert upon the sea, causing it to act as a sort of break upon the rotating solid earth.

Kant, who was by no means a mere "abstract philosopher," but a good mathematician and well versed in the physical science of his time, not only proved this in an essay of exquisite clearness and intelligibility, now more than a century old*, but deduced from it some of its more important consequences, such as the constant turning of one face of the moon towards the earth.

But there is a long step from the demonstration of a tendency to the estimation of the practical value of that tendency, which is all with which we are at present concerned. The facts bearing on this point appear to stand as follows:—

It is a matter of observation that the moon's mean motion is (and has for the last 3000 years been) undergoing an acceleration relatively to the rotation of the earth. Of course this may result from one of two causes: the moon may really have been moving more swiftly in its orbit; or the earth may have been rotating more slowly on its axis.

Laplace believed he had accounted for this phenomenon by the fact that the eccentricity of the earth's orbit has been diminishing throughout these 3000 years. This would produce a diminution of the mean attraction of the sun on the moon, or, in other words, an increase in the attraction of the earth on the moon, and, consequently, an increase in the rapidity of the orbital motion of the latter body. Laplace, therefore, laid the responsibility of the acceleration upon the moon; and if his views were correct, the tidal retardation must either be insignificant in amount, or be counteracted by some other agency.

Our great astronomer Adams, however, appears to have found a flaw in Laplace's calculation, and to have shown that only half the

* "Untersuchung der Frage ob die Erde in ihrer Umdrehung um die Achse, wodurch sie die Abwechselung des Tages und der Nacht hervorbringt, einige Veränderung seit den ersten Zeiten ihres Ursprunges erlitten habe, &c."—Kant's 'Sämmtliche Werke,' Bd. i. p. 178.

observed retardation could be accounted for in the way he had suggested. There remains, therefore, the other half to be accounted for; and here, in the absence of all positive knowledge, three sets of hypotheses have been suggested:—

a. M. Delaunay suggests that the earth is at fault, in consequence of the tidal retardation. Messrs. Adams, Thomson, and Tait work out this suggestion, and, "on a certain assumption as to the proportion of retardations due to the sun and the moon," find the earth may lose 22 seconds of time in a century from this cause. (Sir W. Thomson, *l. c.* p. 14.)

b. But M. Dufour suggests that the retardation of the earth (which is hypothetically assumed to exist) may be due in part, or wholly, to the increase of the moment of inertia of the earth by meteors falling upon its surface. This suggestion also meets with the entire approval of Sir W. Thomson, who shows that meteor-dust, accumulating at the rate of 1 foot in 4000 years, would account for the remainder of retardation. (*L. c.* p. 27.)

c. Thirdly, Sir W. Thomson brings forward an hypothesis of his own with respect to the cause of the hypothetical retardation of the earth's rotation:—

"Let us suppose ice to melt from the polar regions (20° round each pole, we may say) to the extent of something more than a foot thick, enough to give 1·1 foot of water over those areas, or 0·006 of a foot of water if spread over the whole globe, which would in reality raise the sea-level by only some such undiscoverable difference as $\frac{3}{4}$ of an inch or an inch. This or the reverse, which we believe might happen any year, and could certainly not be detected without far more accurate observations and calculations for the mean sea-level than any hitherto made, would slacken or quicken the earth's rate as a timekeeper by one-tenth of a second per year." (*L. c.* p. 27.)

I do not presume to throw the slightest doubt upon the accuracy of any of the calculations made by such distinguished mathematicians as those who have made the suggestions I have cited. On the contrary, it is necessary to my argument to assume that they are all correct. But I desire to point out that this seems to be one of the many cases in which the admitted accuracy of mathematical processes is allowed to throw a wholly inadmissible appearance of authority over the results obtained by them. Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data.

In the present instance it appears to be admitted:—

1. That it is not absolutely certain, after all, whether the moon's mean motion is undergoing acceleration, or the earth's rotation retardation*. And yet this is the key of the whole position.

2. If the rapidity of the earth's rotation is diminishing, it is not

* It will be understood that I do not wish to deny that the earth's rotation *may be* undergoing retardation.

certain how much of that retardation is due to tidal friction,—how much to meteors,—how much to possible excess of melting over accumulation of polar ice during the period covered by observation, which amounts, at the outside, to not more than 2600 years.

3. The effect of a different distribution of land and water in modifying the retardation caused by tidal friction, and of reducing it, under some circumstances, to a minimum, does not appear to be taken into account.

4. During the Miocene epoch the polar ice was certainly many feet thinner than it has been during or since the Glacial epoch. Sir W. Thomson tells us that the accumulation of something more than a foot of ice around the poles (which implies the withdrawal of, say, an inch of water from the general surface of the sea) will cause the earth to rotate quicker by one-tenth of a second per annum. It would appear, therefore, that the earth may have been rotating, throughout the whole period which has elapsed from the commencement of the Glacial epoch down to the present time, one, or more, seconds per annum quicker than it rotated during the Miocene epoch.

But, according to Sir W. Thomson's calculation, tidal retardation will only account for a retardation of 22″ in a century, or $\frac{22}{100}$ (say $\frac{1}{5}$) of a second per annum.

Thus, assuming that the accumulation of polar ice since the Miocene epoch has only been sufficient to produce ten times the effect of a coat of ice one foot thick, we shall have an accelerating cause which covers all the loss from tidal action, and leaves a balance of $\frac{4}{5}$ of a second per annum in the way of acceleration.

If tidal retardation can be thus checked and overthrown by other temporary conditions, what becomes of the confident assertion, based upon the assumed uniformity of tidal retardation, that ten thousand million years ago the earth must have been rotating more than twice as fast as at present, and, therefore, that we geologists are "in direct opposition to the principles of Natural Philosophy" if we spread geological history over that time?

II. The second argument is thus stated by Sir W. Thomson:—"An article, by myself, published in 'Macmillan's Magazine' for March 1862, on the age of the sun's heat, explains results of investigation into various questions as to possibilities regarding the amount of heat that the sun could have, dealing with it as you would with a stone, or a piece of matter, only taking into account the sun's dimensions, which showed it to be possible that the sun may have already illuminated the earth for as many as one hundred million years, but at the same time rendered it almost certain that he had not illuminated the earth for five hundred millions of years. The estimates here are necessarily very vague; but yet, vague as they are, I do not know that it is possible, upon any reasonable estimate founded on known properties of matter, to say that we can believe the sun has really illuminated the earth for five hundred million years." (*l. c.* p. 20.)

I do not wish to "Hansardize" Sir William Thomson by laying much stress on the fact that, only fifteen years ago, he entertained a totally different view of the origin of the sun's heat, and believed that the energy radiated from year to year was supplied from year to year—a doctrine which would have suited Hutton perfectly. But the fact that so eminent a physical philosopher has thus recently held views opposite to those which he now entertains, and that he confesses his own estimates to be "very vague," justly entitles us to disregard those estimates if any distinct facts on our side go against them. However, I am not aware that such facts exist. As I have already said, for anything that I know, one, two, or three hundred millions of years may serve the needs of geologists perfectly well.

III. The third line of argument is based upon the temperature of the interior of the earth. Sir W. Thomson refers to certain investigations which prove that the present thermal condition of the interior of the earth implies either a heating of the earth within the last 20,000 years of as much as 100° F., or a greater heating all over the surface at some time further back than 20,000 years, and then proceeds thus:—

"Now, are geologists prepared to admit that, at some time within the last 20,000 years, there has been all over the earth so high a temperature as that? I presume not; no geologist—no *modern* geologist—would for a moment admit the hypothesis that the present state of underground heat is due to a heating of the surface at so late a period as 20,000 years ago. If that is not admitted, we are driven to a greater heat at some time more than 20,000 years ago. A greater heating all over the surface than 100° Fahrenheit would kill nearly all existing plants and animals, I may safely say. Are modern geologists prepared to say that all life was killed off the earth 50,000, 100,000, or 200,000 years ago? For the uniformity theory, the further back the time of high surface-temperature is put the better; but the further back the time of heating, the hotter it must have been. The best for those who draw most largely on time is that which puts it furthest back; and that is the theory that the heating was enough to melt the whole. But even if it was enough to melt the whole, we must still admit some limit, such as fifty million years, one hundred million years, or two or three hundred million years ago. Beyond that we cannot go." (*L. c.* p. 24.)

It will be observed that the "limit" is once again of the vaguest, ranging from 50,000,000 years to 300,000,000. And the reply is, once more, that, for anything that can be proved to the contrary, one or two hundred million years might serve the purpose, even of a thorough-going Huttonian uniformitarian, very well.

But if, on the other hand, the 100,000,000 or 200,000,000 years appear to be insufficient for geological purposes, we must closely criticise the method by which the limit is reached. The argument is simple enough. *Assuming* the earth to be nothing but a cooling mass, the quantity of heat lost per year, *supposing* the rate of cooling to have been uniform, multiplied by any given number of years, will give the minimum temperature that number of years ago.

But is the earth nothing but a cooling mass, "like a hot-water jar such as is used in carriages," or "a globe of sandstone"? and has its cooling been uniform? An affirmative answer to both these questions seems to be necessary to the validity of the calculations on which Sir W. Thomson lays so much stress.

Nevertheless it surely may be urged that such affirmative answers are purely hypothetical, and that other suppositions have an equal right to consideration.

For example, is it not possible that, at the prodigious temperature which would seem to exist at 100 miles below the surface, all the metallic bases may behave as mercury does at a red heat, when it refuses to combine with oxygen; while, nearer the surface, and therefore at a lower temperature, they may enter into combination (as mercury does with oxygen a few degrees below its boiling-point) and so give rise to a heat which is totally distinct from that which they possess as cooling bodies? And has it not also been proved by recent researches that the quality of the atmosphere may immensely affect its permeability to heat, and consequently profoundly modify the rate of cooling of the globe as a whole?

I do not think it can be denied that such conditions may exist, and may so greatly affect the supply and the loss of terrestrial heat as to destroy the value of any calculations which leave them out of sight.

My functions as your advocate are at end. I speak with more than the sincerity of a mere advocate when I express the belief that the case against us has entirely broken down. The cry for reform which has been raised without, is superfluous, inasmuch as we have long been reforming from within with all needful speed. And the critical examination of the grounds upon which the very grave charge of opposition to the principles of Natural Philosophy has been brought against us rather shows that we have exercised a wise discrimination in declining to meddle with our foundations at the bidding of the first passer-by who fancies our house is not so well built as it might be.

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OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 11th, 1868.

William Augustus Edmond Usher, Esq., Geological Survey of Great Britain; Rev. Robert Dixon, M.A., Nottingham; William Woodman, Esq., The Deanery, Great Malvern; and F. R. Mallet, Esq., Geological Survey of India, were elected Fellows.

The following communications were read:—

1. *Note comparing the* Geological Structure *of* North-western Siberia *with that of* Russia in Europe. By Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., F.R.S., V.P.G.S., &c.

My old associate, Count A. von Keyserling, who, with M. de Verneuil, cooperated with me in producing the work entitled 'Russia and the Ural Mountains,' has recently acquainted me with some phenomena relating to countries beyond the limits of our researches, which are, it seems to me, of sufficient importance to be laid before the Geological Society.

In the expedition undertaken by M. Lahost, to discover the remains of Mammoths *in situ* and other objects on the banks of the Lena, it was clearly ascertained that, besides those comparatively modern deposits in which bones of these animals are found, a vast tract of country lying between the rivers Lena and Jenissei is occupied by Upper Silurian rocks, which, judging from their organic remains, are of the same type as those collected by Keyserling on the river Vachkina, in the region of the Petchora, and described by him in our joint work.

Among the formations younger than the Silurian are Carboniferous rocks, some of which contain beds of coal several fathoms thick, whilst cupriferous schists and graphite also occur.

In alluding to the highly important researches of that good palæontologist Schmidt, who has been exploring several parts of Siberia, Count Keyserling states that he is of opinion that the chief masses of the Secondary deposits which have been observed in Northern Siberia are not, as Eichwald supposes, of Cretaceous age, but that on closer examination their fossils will be found to agree with those of Oolitic or Jurassic type, of which an account is given by Keyserling in 'Russia in Europe and the Ural Mountains,' *i. e.* the remains derived from the Petchora region, which is the next adjacent tract on the west to the Siberian region in question.

This view is maintained by the fact that Lindström has described exactly analogous fossils from Spitzbergen, from rocks which overlie Triassic deposits. At the same time it is to be noted that these fossils are somewhat peculiar, and should be classed as the Arctic types of the Mesozoic formations of that age.

It has been ascertained by M. Schmidt that the banks of the Jenissei, as well as those of some of its affluents, are occupied by Postpliocene accumulations, similar to those which my associates and self found lying on Palæozoic limestones at Ust Vaga and other places on the borders of the great river Dwina, at Archangel.

I have called attention to these recent observations, because from them we learn that the classification which my friends and self applied to Russia in Europe has a still wider application, extending far to the Asiatic side of the Ural Mountains. That zone of eruptive, disturbed, and metamorphic rocks being passed over, many of the sedimentary formations which occupy wide spaces in Europe, reappear again in their normal European characters, and occupy vast spaces in Siberia.

It is right to add that M. Schmidt (whose health, I regret to hear, suffered much in making these adventurous journeys) has come to the conclusion that Mammoths lived in Northern Siberia; for, judging from the remains of the fossil and semifossil trees of the region, he infers that in the days of those huge elephants the climate of Siberia was somewhat more temperate than at present, and that after the Glacial epoch the cold was for a time mitigated.

These additional data respecting the extension into Siberia of vast and slightly undulating, and to a great extent horizontal and unbroken formations, which each respectively occupy such wide areas, lead to the inquiry what can have been the deep-seated cause which, excepting along the north and south axis of the Ural Mountains, has prevented the extrusion through the crust of the globe of those igneous rocks which have at various periods so highly diversified the outlines of numerous geological formations in many other parts of the globe.

When speculating on the intervening matter which may have checked the issue of such igneous materials over so wide an area, the late Leopold von Buch once suggested to me, in conversation, that possibly at some very remote period a vast sheet of hypersthene or other submarine volcanic matter may have so spread over the surface of the lower or more central regions of the Palæozoic deposits as, on condensing, to form a bar to to all future outburst, and thus save these vast regions from the earthquakes, dislocations, and ruin which have for ages affected all those countries wherein the issue of such internal forces is not checked, and particularly where great fissures or deep longitudinal cracks in the crust exist.

The Ural Mountains, lying as they do between two vast undisturbed regions, and replete as they are with many varieties of such eruptive rocks, afford a fine illustration of this view.

So also at several points around the centre of Russia in Europe, as in the environs of Petrozavodsk and the Lake Onega in the north, and in the region of the Southern Steppes.

It is within these zones of subterranean disturbance that the huge and wide-spread deposits of Russia and Siberia exhibit unquestionable proofs that they have been disturbed violently. They have simply undergone equable movements of elevation and depression, and exhibit strata of very high antiquity, often covered with Postpliocene and arctic deposits, which, if we judged merely from the conformity of their mutual arrangement, might be supposed to be of the same or nearly the same age, though in reality they were separated by long epochs in time.

In regard to the geology of Russia in Europe, Count Keyserling informs me that M. Grewinck has discovered white fossiliferous chalk in parts of the great Sarmatian plain, where its existence was unknown owing to the cover of Quaternary and allied deposits :—

1. At Baltishke, north-east of Kovno, and near the banks of the river Noveja, where the rock is covered by 4 or 5 feet of Quaternary deposit, it contains the following fossils—*Rotulina trachyomphala* (Reuss), *Cristellaria rotulata* (Lam.), *Rotulina polyraphis* (Reuss), *Fromentulina levigata* (Römer), *Bulimina intermedia* (Reuss), *Textillaria globifera* (Reuss), *Globigerina cretacea* (D'Orb.), *Frondularia*, *Dentalina*, *Cytherea*, of species not determined, with species of Echinoderms and large *Inocerami*. 2. At Melden, a country-house in Courland, on the river Lendisk, below Nigrande, where, beneath a cover of lignite, beds of chalk with several of the above-mentioned fossils, including *Inocerami*, repose on Permian rocks.

These Cretaceous rocks, separated by great distances, seem closely to resemble those of Lemberg in Gallicia, and of Grodno in Russia ; so that we may infer that, originally, the chalk formation had a very wide extension in this region, whilst we know that it appears in force low down the Volga and in the Government of Orenburg. Its denudation in the two localities cited accounts for the great admixture of chalk flint which is found in the so-called drift of these tracts.

M. Grewinck has also made inquiries into the real source of the vast quantities of amber which are found on the beach or by dredge along the shore near Memel*. He suggests that it may be carried down by rivers into that sea from the deposits of that age which occupy the large adjacent region of Russia and Poland. I am the more disposed to believe that these interior tracts are truly those

* [On this point see Dr. Zaddach's memoir on Amber, translated in 'Quarterly Journal of Science' for April.—H. M. J.]

whence the amber has been derived from what came under my own notice. The late Emperor Nicholas presented to me a mouthpiece of a pipe formed out of a block of amber which was dug out in his presence, at a depth of 18 feet, in the province of Grodno. On asking me if I was aware of amber occurring in that region, I opened the Geological Map of Russia prepared by myself and friends, and, pointing to the yellow colour which extended from that province to the Baltic Sea, I directed His Majesty's attention to the word amber inscribed on the coast-line as being found in these Tertiary deposits.

Discussion.

Sir Roderick Murchison, in explanation of the paper, referred to a geological map of Russia, and gave a general sketch of the bearing of the paper on the previously known geology of that country. He mentioned the discovery by M. Grewinck of beds of brown coal containing amber, and overlying true chalk. The amber in the Baltic had been supposed to have been washed out of beds beneath the sea; but Count Keyserling has suggested that the amber may have been brought down by the rivers from the interior, and deposited in the Baltic. Sir Roderick also called attention to the absence of igneous rocks in Russia to the west of the Ural Mountains.

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2. *On a Section of a* Well *at* Kissingen.

By Dr. F. Sandberger, For. Corr. G.S.

[Communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., F.G.S.]

(Abstract.)

The beds which have been pierced by the bore of the Schönborn Well (2001 feet 9 in. in depth) at the Upper Salinen, near Kissingen, have already been several times described, but, in the author's opinion, not in a manner which has led to a clear knowledge of them. He therefore examined carefully the specimens which still retained the original labels, and even conveyed them to Würzburg for analysis.

He considered it highly desirable, in the first place, to ascertain a datum-line remaining constant over a wide area; and such he determined to be the blackish-blue limestone which was bored through at the depth of from 1698 to 1740 feet (see Section, p. 6). It consists of two varieties—one pyritous and the other free from bisulphide of iron. The colour is deep blackish grey, the structure close, and the fracture almost conchoidal. A quantitative determination gave 60·20 per cent. of carbonate of lime, and 17·22 per cent. of carbonate of magnesia. The rock is therefore a very bituminous and argillaceous dolomite. It corresponds accurately with the uppermost bituminous Plattendolomit of the Zechstein of the Hartz and Thuringia, and with hand-specimens from Eisenach, Aschaffenberg, and Gera.

The upper boundary of the Zechstein-formation having been thus fixed, it follows that the strata overlying the above-mentioned Plattendolomit, and ranging from a depth of 1590 ft. 9 in. to 1698 ft. 10 in., belong to the lowest part of the Bunter Sandstone; while those that immediately underlie it, at a depth of from 1740 to 2001 feet, must be referred to the upper region of the Zechstein.

The limestones which were so repeatedly raised during the boring caused the reference of the former series to the Zechstein; but the author states, as the result of his examination, that they differ in all their relations from the deeper limestones occurring at 1698 feet and upwards, and, on the other hand, correspond in none of their characters with the Plattendolomit (the uppermost member of the Zechstein), and that they therefore belong to the Bunter Sandstone.

Limestones being particularly abundant in the lowest portion of the Bunter Sandstone in Thuringia and in the district of Magdeburg, and occurring even in two forms, viz. (1) as "Rogenstein," often very coarse-grained, and (2) as close or fine-grained so-called "Hornkalk," the author concludes, from the comparison of a very complete series of them, that the "Hornkalk" corresponds entirely in petrographical and chemical characters with the beds in question,—and also that beds of rock-salt, analogous to those of Stassfurt or Schönebeck*, cannot be reckoned upon in Franconia; for the strata in which they lie are but slightly developed on the southern margin of the Thüringer-Wald, and at the best contain very little saline matter.

Below the Plattendolomit of the Zechstein, from the depth of 1740 feet to 1884 feet follow saline clays of red, bluish, and brownish colour, which appear to be traversed by lines of anhydrite, or of white gypsum. Boiling water extracts from them a tolerably large quantity of alkaline chlorides (one specimen of the red saline clay yielded 3·21 per cent. of chloride of sodium with very little chloride of potash), and little of the sulphates; they are evidently the principal source of the saline contents of the Kissingen wells.

The still deeper anhydrite, from 1884 to 2001 feet, is dirty bluish-grey, very hard, and here and there contains druses, in which crystals of the mineral appear to have been formed.

At a depth of 2001 feet the boring was discontinued, in consequence of the breaking and jamming-in of the chisel; and the question therefore still remains, whether the anhydrite forms the base of the salt-bearing beds of the Zechstein in Franconia, or whether it is only an intercalated bed between an upper very poor deposit, which owes its importance entirely to the mineral waters which derive their salt from it, and a lower and richer rock-salt formation.

That this is possible appears, *e. g.*, from the fact that in the Triassic deposits of Baden and Lothringen the salt-bearing portion contains several divisions of the pure rock-salt beds, which are

* A very complete memoir on Schönebeck is that by C. v. Alberti in the Zeitschr. d. deutschen geol. Gesellschaft, vol. xix. 1866, p. 373, which gives the most striking proof of the rock-salt in question belonging to this series of beds, as shown by many well-sections.

separated from one another by very thick beds of gypsum, particularly striking at Dürrheim in the Schwarzwald, near Dieuze, and at several other places in Lothringen.

It is difficult to believe that while there exists a thickness of 24 feet of pure rock-salt, associated with saturated brine, on the borders of the Franconian basin near Salzungen, at the neighbouring Neustadt well, which yields saturated brine, and at the Kissingen well further towards the centre, only poor saline clay should have been deposited. It is far more probable that a thick rock-salt deposit is hidden beneath the Anhydrite, and would probably soon have been reached by a continuation of the boring in the Schönborn shaft, and thus have shown the future of the Kissingen saline wells.

In conclusion the author epitomizes the results of his researches upon the section in the Schönborn-well in the accompanying section, and discusses the most probable mode of the formation of the Kissingen wells, the succession of the rocks, and their chemical condition.

Section of the Schönborn Well at Kissingen.

Formations.	Rocks.	Thickness. ft.	in.	Depth. ft.	in.
Liver-shale of the Lower Bunter, with so-called "Hornkalk" and Gypsum.				1590	9
	Limestone	17	11	1608	8
	Granular and Crystalline Gypsum	16	1	1624	9
	Limestone	4	1	1628	10
	Compact Gypsum	2	9	1631	7
	Red clay-shale alternating with Limestone, Marl, and Gypsum	67	3	1698	10
Bituminous Plattendolomit of the uppermost Zechstein.	Compact limestone with bisulphide of iron	3	2	1702	0
	Bluish-black Limestone	38	0	1740	0
Saliferous marls of the uppermost Zechstein.	Red saliferous clay with Gypsum	35	1	1775	1
	Blue saline clay	34	11	1810	0
	Brownish clay with Gypsum, saliferous	2	0	1812	0
	Salt-rock	12	3	1824	3
	Salt-rock with Gypsum	7	9	1832	0
	Salt-rock with Gypsum and Anhydrite	52	0	1884	0
Anhydrite	Anhydrite	115	0	1999	0
	Anhydrite alternating with Gypsum	2	9	2001	9

Discussion.

Sir R. I. Murchison differed from the author on one point only. He regarded the upper member of these saliferous rocks, which is overlain by 1500 feet of Bunter Sandstone, as completely separated from that formation, and as forming the upper part of the Permian group.

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3. *On the* Formation *of* Deltas; *and on the* Evidence *and* Cause *of* great Changes *in the* Sea-Level *during the* Glacial Period. By Alfred Tylor, Esq., F.L.S., F.G.S., &c.

(Abstract.)

The first portion of this paper is devoted to a comparison of the delta-deposits of the Po, Mississippi, and Ganges, by means of the descriptions of the strata obtained from borings in their deltas for water.

The surfaces of these deltas and the alluvial plains above them are compared together with reference to their inclination and height above the sea-level; and it is found that a parabolic curve drawn through the extremities of each river, and through one point in its course, nearly represents its longitudinal section, the greatest deviation being 30 feet in some of the largest deltas.

The delta-deposits are found to be coarser and more sandy near the bottom, indicating that the rivers were more rapid during the earlier portion of their existence.

Messrs. Wheatley and Abbott's descriptions of the delta of the Mississippi are compared with those of earlier writers; and a description is given, from their work, of the late extensions of the delta into the Gulf of Mexico.

The formation of delta-deposits is explained by the hypothesis of a change in the level of the sea, instead of in the level of the land and sea-bottom.

The littoral deposits around Great Britain are investigated by the author, to ascertain if his hypothesis, of a fall in the sea-level of 600 feet during the Glacial Period, is tenable.

Some evidence of the extent of the Glacial Period is given; and the ice-cap hypothesis advocated by Mr. Croll is alluded to as a probable cause of a great reduction in the level of the sea through abstraction of water from the sea, and its deposition at the poles in the form of ice.

The positions of the fossiliferous strata of the Quaternary Period are discussed with relation to Mr. Godwin-Austen's former suggestion of a great river where the German Ocean now is, formed by the junction of the Rhine, Thames, and Humber. The probable age of the Straits of Dover is also alluded to.

Prof. Forbes's examination of the fauna and flora of the British Isles, with a view to the determination of the sources of Alpine plants, induced him to believe that the British plants and animals migrated from Scandinavia, Germany, and France at different periods, some before and some after the Glacial Period; and the

hypothesis of a fall in the sea-level, in the author's opinion, accords better with the facts described than Professor Forbes's supposition of changes in the level of the land and sea-bottom.

If Mr. Tylor's hypothesis is correct, that there has been a fall of the sea-level of 600 feet during the Glacial period, followed by an equivalent rise, we ought to find evidence of dry land, of rivers, or, at least, of littoral conditions on the bottom of the sea within the 100-fathom line of soundings.

We should not expect to find a very continuous and unbroken land-surface preserved, as in the upward movement of the sea much ground would be covered with deposits of clay, and shingle, and sand, and much of the old surface removed by currents and waves.

Sir Henry De la Beche, Professor Edward Forbes, and Mr. Godwin-Austen have investigated the present condition of the sea-bottom round the British Isles; and in their writings are to be found many observations of facts that may be as conveniently explained by the hypothesis of the change in the sea-level as by that of a change in the level of the land and sea-bottom.

Taking the facts as they stand in the writings of these authors, who have all treated the subject most skilfully, the hypothesis of a gradual fall in the sea-level of 600 feet, the author thinks, explains them equally well or better than that of local elevations and then depressions to exactly the same point. The great difficulty in Professor Forbes's argument was to get the Scandinavian flora across the sea. It was necessary to suppose that the space now occupied by the German Ocean was elevated (of which there is no proof), in order to provide dry land for the plants to pass over. The Glacial Mollusca were found by Professor Forbes living in the deeper portions of the German Ocean, which, the author thinks, showed that there could have been no great elevation of the sea-bottom. Whether the sea-level were reduced or the land raised 600 feet, would have the same effect in producing changes of climate and increased excavating-power of rivers; and he thinks that all the phenomena of a great northern river receiving the waters of the Rhine, Thames, Humber, &c. would occur as described by Mr. Godwin-Austen, if the sea-level were depressed 600 feet.

Mr. Gwyn Jeffreys has lately recorded the discovery of specimens of fossil Arctic shells off the Shetland Isles in about 90 fathoms water. The following species were found by him in dredging, and are arranged in the order of their abundance:—

Terebratula Spitzbergensis.	Trochus cinereus.
Rhynchonella psittacea.	Mölleria costulata.
Pecten Islandicus.	Trophon clathratus.
Tellina calcarea.	Columbella haliæeti.
Mya truncata, var. Uddevallensis.	Pleurotoma pyramidalis.

All these shells are found fossil in Sweden, and living in the extreme Arctic seas. None of these species are ever found in deep water; so that their presence, scattered over a wide area of sea-bottom, is remarkable, and corresponds with the discovery of shingle and littoral shells in the English Channel at similar depths. The littoral shells of the English Channel are not Arctic species, as are those in the German Ocean; and this fact is a proof that the former were deposited on the sea-bottom of the English Channel before the junction of the English Channel and German Ocean at the Straits of Dover was effected.

The discovery of these nine species of fossil shells by Mr. Gwyn Jeffreys at a depth of 90 fathoms, off the Shetland Islands, is an important addition to Forbes's and Godwin-Austen's observations. This discovery affords independent and corroborative proof of identical conditions with those observed by these authors in other parts of the sea-bottom; and it establishes the existence of littoral conditions in the Quaternary period near the present 100-fathom line in the North Sea, and is therefore an additional support to the hypothesis we are considering.

A fall in the sea-level of 600 feet would not only produce littoral conditions off Shetland, without any change of level of the sea-bottom, but would tend to lower the temperature of the air very much, and also to increase the rainfall. There are certain conditions under which a rainfall of 300 inches per annum might be produced in our climate; but they would involve the summer heat being 130° Fahrenheit near the locality of a mountain-range of from 1500 to 2000 feet in height. The amount of rainfall depends greatly upon the high temperature of the air at the sea-level (supposing it saturated with moisture) and the low temperature of the air on the mountain-range intercepting the aerial currents.

We might have in our latitude a summer heat of 130° from the general elevation of the heat of the globe, from an increased volume of the Gulf-stream, and from a greater prevalence of the west and south-west winds.

The pluvial period which the author had previously proposed, and which was so much objected to in the discussion of May last, does not require any greater volume of water than has been before suggested by geologists, as heights of 80 feet were estimated for the ordinary difference of winter and summer floods in passages of two different memoirs by Mr. Prestwich, as occurring during what he considers the earlier part of the gravel-period *.

There is, however, in England no appearance of tropical vegetation in the Quaternary deposits, such as we should expect would accompany a temperature of 130°; and we must therefore try some other alternative.

We could not have rivers varying 80 feet in summer and winter without some such rainfall, unless we had pluvial and tidal conditions very different from those now in the Thames and Somme Valleys. What we want is to explain the enormous rise of rivers in a cold climate during the Quaternary period.

In the year 1840 the ice brought down by a January flood, gorged at a point about nine miles from the mouth of the Vistula, cut a

* [See Abstract of a paper, by Mr. Prestwich, on the Loess of the Valleys of the South of England and the Somme, read June 19, 1862, Proceedings of the Royal Society, vol. xii. p. 170.]

channel through the sand-hills to the sea. This is now the mouth of the Vistula, that passing Dantzic having been turned into a canal*.

I do not intend here to discuss the question of subsidences and elevations which have affected the surface of the earth so largely, and have no doubt occurred in some localities during the period under consideration. I would, however, remark that in Wealden, Eocene, or Miocene deltas there is no instance of any large fluviatile deposit having been elevated or depressed *evenly* over a large area; while all over the world a perfectly even movement of subsidence is supposed to have taken place just at the mouths of large rivers in the Quaternary, or most recent, period, in order to account for modern freshwater delta-deposits containing shells living in the adjoining seas being now found hundreds of feet below the sea-level.

It would be the safer plan, in considering the remarkable gravel- and crag-deposits which characterize so distinctly the Quaternary period, to infer the size of rivers, amount of rainfall, and elevation of tides from the deposits themselves. Further acquaintance with meteorological phenomena may find a fitting explanation of the difficulties we meet with in explaining the position of the gravel at such heights above our present streams and freshwater clay, and sands at such depths below the sea-level.

If the hypothesis we have been considering is a true one, that the sea-level fluctuated 600 feet in the Glacial period, falling gradually and then rising again to its former level, we ought to find the best evidence in the Pacific Ocean among the vast littoral accumulations of the coral-zoophytes.

The same theory of gradual subsidence, as was proposed for explaining the delta-deposits, has been applied to explain the formation of the remarkable coral-islands over a tract of ocean 5000 miles long. The sea-bottom by this theory is supposed to subside so regularly and slowly that the coral-zoophytes build up their reefs and coral-banks at an equal rate with the fall of the sea-bottom.

Mr. Croll's hypothesis of an immense mass of ice at the poles sufficient to make the polar diameter equal to the equatorial (Phil. Mag. p. 302) is well known. He has (p. 305) assumed that the quantity of liquid water would be unchanged, as the ice in the southern hemisphere would be transferred to the northern hemisphere.

The author's hypothesis is different.

He thinks the geological evidence of a Glacial period indicates an immense collection of ice at the north pole, accompanied by a low temperature in the tropics, and probably a very low temperature at the same time at the south pole.

This would involve the supposition of a fall in the ocean-level in proportion to the quantity of ice collected at the poles.

It is of course doubtful what quantity of water was abstracted from the ocean in this Glacial period (which Mr. Croll considers

* Pfeiffer, 'On the Vistula,' Dantzic, 1849. The gorging of ice at the mouth of the Thames, Seine, and Somme may have assisted in the production of some of the remarkable gravel-beds in these rivers.

commenced 240,000 years ago, and lasted 160,000 years), and was stored up in the polar regions in excess of the quantity now existing there or what existed previously.

This excess must have been an enormous quantity; and if equal surfaces of the globe were covered with ice and with water, then every foot of the average thickness of ice stored up in the polar regions above the former surface-level would cause an immediate fall of the sea-level also of one foot.

The author's supposition of a fall in the sea-level of 600 feet does not appear to him excessive, if the Glacial period was so important as we have reason to suppose it to have been.

Discussion.

The President called attention to the fact that in the neighbourhood of coral reefs the dead corals extend to such a vast depth that, supposing them all to have been formed near the surface, and that surface only lowered by abstraction of water to the Poles, the accumulation of ice must have been so great as to become incredible.

Sir Charles Lyell had already suggested to Mr. Croll that, assuming the accumulation of ice at the Pole depressing the centre of gravity of the earth, the submergence that would have resulted had the quantity of water in the sea remained the same would, to some extent, be counteracted by the reduction in volume consequent on the formation of the ice. With regard to the delta of the Mississippi, the data on which he argued had considerably altered since first he wrote on the subject, inasmuch as recent calculations had doubled the estimated volume of water flowing into the sea, and thus it was capable of producing the same effect in half the previously calculated time. The progress of the delta at any spot was of necessity variable, as the position of the mouth changed. The American engineers had allowed only 40 feet as the depth of the fluviatile deposits, whereas from boring Sir Charles had concluded it to be at least 500 or 600 feet. There was now reason to suppose that it was much more, possibly as much as 1500 feet. This being the case, notwithstanding the amount of work done by the river being doubled, his calculation as to the time required for the formation of the delta might not after all be so excessive.

Mr. Prestwich suggested that Mr. Croll's theory involved probably a transfer of ice from one Pole to the other, and not only a diminution of volume of the sea. The raised beaches round the coast of Britain varied considerably, and were not on one uniform horizon, as they must have been had they resulted from a lowering of the sea. The elevation of the old sea-beds during the Glacial period could not be accounted for by any supposition of the mere alteration in the volume of the sea.

Mr. Evans pointed out that, the *Cyrena* being a freshwater shell, its position at a certain level was not connected directly with the height of the sea. He doubted the curve of the rivers being in all cases parabolic.

Mr. Mallet had remarked that nearly all river-courses are in longitudinal section hollow curves which do, in their upper reaches at least, appear to present more or less of the character of parabolas. But although the well-known formula which expresses the discharge at each point, and in fact the regimen of the stream, might seem *à priori* to countenance the idea that these curves are parabolic, he is much disposed to think that the form of water-channel does not depend upon any hydrodynamic law, but simply upon the natural contour of the longitudinal sections of the river-courses, which run almost always on the bare rocky skeleton of the earth, and follow the forms, viewed on a broad scale, of all rocky anticlinals, whose slopes are always more or less hollow curves. As regards the long gently sloped lower reaches of all rivers, and more particularly of great rivers, such as those appealed to by the author, Mr. Mallet believed that it would be perfectly impossible to affirm that their longitudinal sections conformed to any particular curve. When plotted, such sections will be found to fit equally well to right lines, or, if curved, to parabolas, ellipses, arcs of circles, or what we please.

Mr. Tylor replied that he had not found definite evidence as to the extension of corals downwards to such a depth as that mentioned by the President. With regard to oscillation, he had merely treated of the southern part of England. The opening of the Straits of Dover would account for the existence of beaches above the present level, as the tides would have previously risen higher. The parabolic curve was that which, by actual comparison, coincided most closely with the longitudinal section of the banks of the rivers Po, Mississippi, and Ganges.

November 25th, 1868.

The following communications were read:—

1. *On* Floods *in the* Island *of* Bequia. By G. M. Browne, Esq.

(Communicated by the Secretary of State for Foreign Affairs.)

[Abstract.]

On the 17th of March, at 8 o'clock p.m., a steady strong wave was seen bearing down upon Admiralty Bay; it had no perceptible crest, and was 3 feet in height; it encroached upon the land to distances varying from 70 to 350 feet. A second, smaller wave followed. No shock of an earthquake was felt.

Discussion.

Dr. Duncan wished for some explanation of these earthquake-waves, more especially with regard to the effects of supposed cataclysmic waves. He considered that they arose from sudden changes in the level of shoals or littoral tracts, and not from deep-sea disturbances.

Mr. Babbage suggested that, assuming an eruption of lava at the bottom of the ocean, there might be such an amount of steam generated, or even such a decomposition of water, as would originate waves of enormous volume.

Sir C. Lyell was inclined to the same opinion, and not to limit the causes of these waves to oscillations of the surface of the earth.

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2. *Description of* Nga Tutura, *an extinct* Volcano *in* New Zealand. By Captain F. W. Hutton, F.G.S.

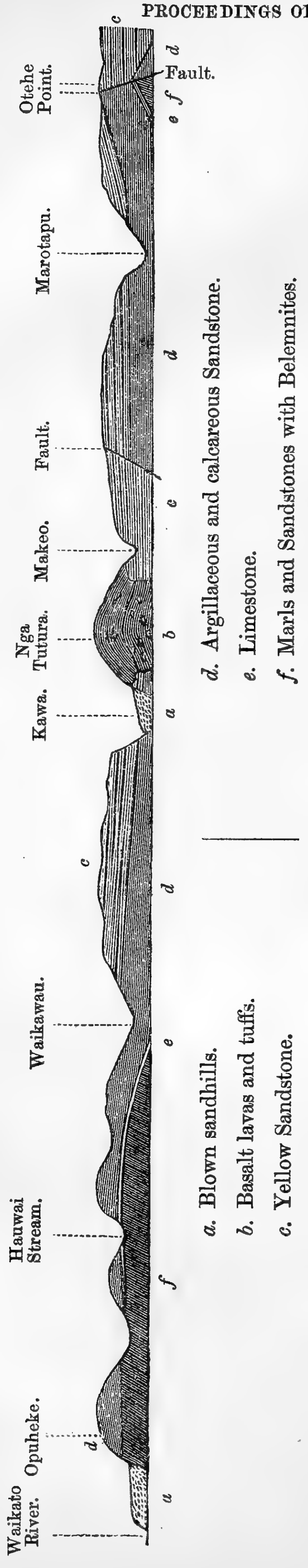
On the west coast of the North Island of New Zealand, between Raglan and the mouth of the river Waikato, there exists an extinct volcano, called Nga Tutura, which, owing to its position on the sea-cliff, is of considerable interest.

The south head of the Waikato is composed of a series of indurated shales and sandstones, containing *Belemnites Aucklandicus*, Hauer, *Ancella plicata*, Fitt., and many fossil ferns. This series is supposed to be of Upper-Mesozoic age, and has here a dip of about 35° N.E. As we follow these beds along the coast in a south-easterly direction, we find their upper surface remaining tolerably level for about four miles, when the dip changes to the south-east, and in half a mile more they have descended below the sea-level, not to be seen again until we arrive at Otehe Point, about halfway between the Waikato and Raglan, where they just make their appearance dipping north, and are immediately cut off by a fault.

Upon these beds Tertiary rocks lie unconformably, the lower portion being considered of Miocene age. First comes a coarse-grained limestone, six or eight feet thick, often passing almost into a conglomerate at its base, but more pure and consisting of fragments of shells and corals and rolled pieces of limestone at the top, and containing *Fasciculipora mammillata* (Fitt.). This limestone thins out to the north, and is covered by a bed of argillaceous and calcareous sandstone, about 100 feet thick, containing *Schizaster rotundatus*, Fitt., *Scalaria lyrata*, Fitt., *Pecten Williamsoni*, Fitt., &c. This bed gets coarser-grained and more siliceous to the north, and more calcareous to the east. Upon it rests a bed of red or yellow sandstone, sometimes 300 feet thick, interbedded in places with seams of blue clay. These clay beds, and occasionally the sandstone itself, contain the remains of existing plants; and therefore their age is, probably, Newer Pliocene. This series of Tertiary rocks is horizontal at the mouth of the Waikato; but further south, where the older rocks begin to dip to the south-east, these newer beds partake also of the same movement, dipping strongly near Waikawan to the south-east, then becoming horizontal, but again dipping 10° S.E. when they reach Kawa. From this point they keep nearly horizontal, broken once only, near Makeo, by a fault, until, on reaching the Otehe Point, they rise up again at the same angle as the upper surface of the Secondary rocks, and are traversed by the same fault.

Very nearly in the centre of this synclinal, the rocks are broken

Section on the coast from the Waikato River to Otehe Point (15 miles).



through by the basaltic cone of Nga Tutura. This hill is about 600 feet high, with a gently rounded summit, showing, from the land side, no sign of its volcanic origin. On the sea-shore, however, at low tide, one is able to climb out on the fallen masses of basalt, and examine its internal structure. In this way it is seen that the volcano has burst through the rocks without upturning their edges in the least, and covered them with accumulations of tuff and lava. The lower part is filled with ashes and scoriæ, enclosing large irregular blocks of the yellow sandstone, and dipping (roughly) N.W. and S.E. from the centre. Above, the hill is chiefly composed of lava streams of basalt, containing olivine, with but little tuff, which fact and the denuded outline of the cone seem to show that the eruptions were submarine.

From the foregoing description it is evident that both the formation of the synclinal and the eruptions of the volcano took place subsequent to the deposition of the yellow sandstone; but there is no evidence to show whether the synclinal movement was before or after the eruption. Still, as we cannot suppose that subsidence took place while the pressure below was so great that it found vent in breaking through the overlying rocks, it seems to follow that they must have sunk down after the volcano had exhausted its energy, and that at the same time the portion between the volcano and the fault south-east of it fell through lower than the rest; and, as I cannot imagine that a synclinal of so small an extent (only 10 miles) could be caused by subsidence into a cavity at a considerable depth, the conclusion appears to me to be irresistible that, in this case at least, the fluid matter that escaped as lava was not connected with a melted interior of the earth, but was derived from rocks not more, perhaps, than 1000 feet below the surface. It might, indeed, be urged that the synclinal was not caused by subsidence at all, but by the elevation on both sides when the land was rising above the sea, while the centre was held down by the rivet-like form of the pipe and cone of the volcano. If such an argument should really be advanced in earnest, it would be, I imagine, sufficiently answered by the fact that the pipe of the volcano is almost entirely composed of loose ashes, and not at all equal to bear the strain necessary for such a task.

Discussion.

Mr. David Forbes could not see that the author had brought any conclusive proof that the lava was derived from so inconsiderable a depth. From his examination of the lavas of Polynesia, of Europe, and of other localities, he was satisfied that their chemical constitution was the same, and therefore that their products were derived, not from any merely local sources, but from some more or less connected extensive internal reservoir. In answer to Sir C. Lyell, he showed, from the eruption of Santorin, that the trachytic and basaltic lavas came from the same source, inasmuch as they issued from one and the same crater.

Mr. W. W. Smyth was gratified that the new system of education of military officers was productive of such good results in a geological point of view.

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3. *On* Dakosaurus. By J. Wood Mason, Esq., F.G.S.

(The publication of this paper is unavoidably postponed.)

[Abstract.]

The Kimmeridge Clay of Shotover Hill has yielded five specimens of the teeth of this reptile, now for the first time represented as a British genus. After noticing the bibliography of the subject, and the presence of specimens in various museums, the author proceeds to describe the characters of the teeth. They are large, conical, incurved, and slightly recurved, having two sharp, prominent, crenulated, longitudinal ridges, which are situated midway between the convex and concave curvatures.

This reptile is regarded by the author as foreshadowing the form of dentition that characterizes the existing group of *Varanidæ*. If the materials were at hand for a complete definition of its comparative osteology, *Dakosaurus* would probably exhibit a combination of Lacertilian and Crocodilian characters, but with the crocodilian elements predominant.

Discussion.

The President differed from the author as to the conclusions he drew from the structure of the teeth. The teeth of existing Crocodilia had been but imperfectly described, and he thought he could point out among existing Crocodiles teeth bearing the character which the author regarded as Lacertilian. He agreed with Prof. Owen in regarding *Dakosaurus* as Crocodilian rather than Dinosaurian or Lacertilian.

Mr. Wood Mason had seen in the Gavial of the Ganges, and in the teeth of Teleosaurians from the neighbourhood of Oxford, the same crenulations and compression, which he regarded as indicative of a Lacertilian character.

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4. *On the* Anatomy *of the* Test *of* Amphidetus (Echinocardium) Virginianus, *Forbes; and on the Genus* Breynia. By P. Martin Duncan, M.B., F.R.S., Sec. G.S., &c.

(This paper was withdrawn by permission of the Council.)

[Abstract.]

After a careful examination of the Miocene *Amphidetus* from the Virginian Tertiaries, the author regarded the recent species of the genus from the European and Australian seas as a group of very closely allied forms. The Crag specimen of *A. cordatus*, described by Forbes, could not be found; but the examination of a series of recent specimens decided that they were not specifically different from the Miocene form.

The unusual form of the ambulacral spaces, the nature of the fasciole crossing them, and the resulting absence (more or less) of pores within the fasciole were asserted to be of third-rate value as regards structural importance; and the author did not consider that the genera *Echinocardium, Breynia, Lovenia*, &c. had a common origin, or that there was a close genetic relationship between them, because they had this fasciolar structure. He considered the fasciole to be an appendage to several generic groups which were distinctly separated by other structural distinctions. An examination of the Nummulitic *Breyniœ* in the Society's collection satisfied Dr. Duncan that there were only race characters separating them from *Breynia Australiensis*—a recent Echinoderm. The persistence of these species, widely distributed, and of great geological age, was very remarkable.

Discussion.

The President regretted, with the author, the prevailing custom of determining species as much by their geological position as by their structural affinities. He thought it was necessary to have a knowledge of living forms, in order to estimate correctly the value of the characters of extinct species. He considered that the presence

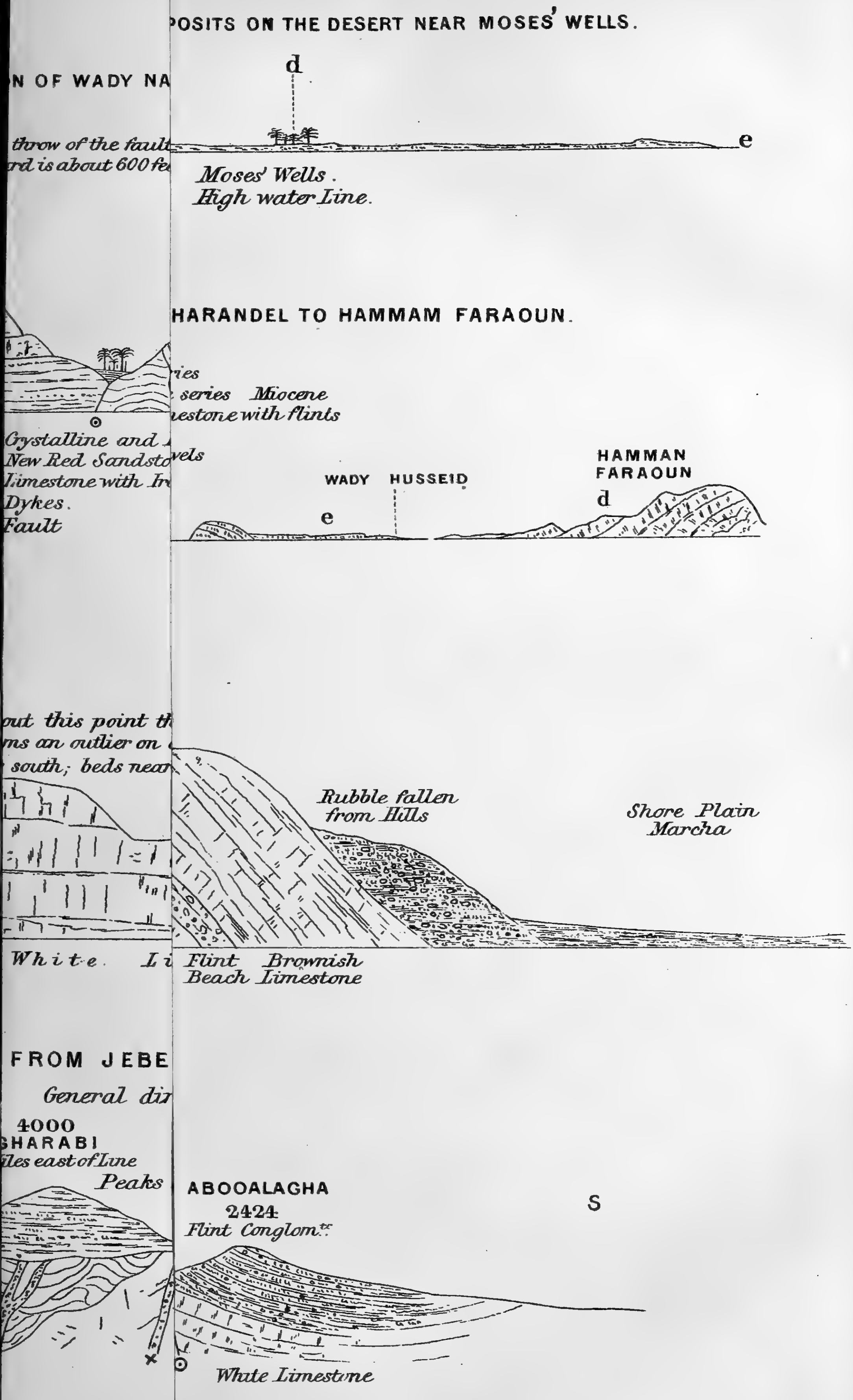

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Fig 6. SKETCH MAP of the OLD COPPER AND TURQUOISE MINING DISTRICT in ARABIA PETRÆA

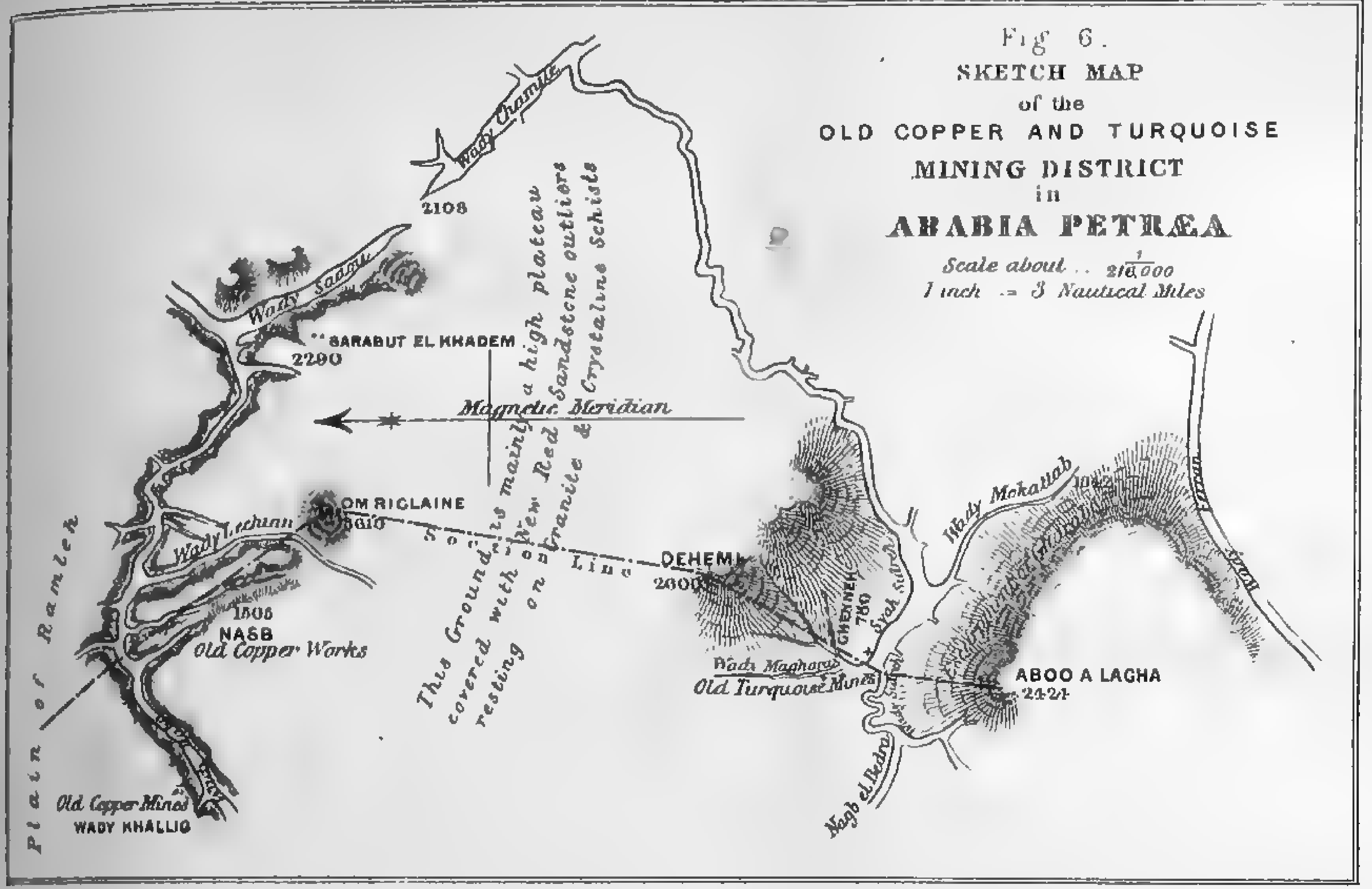
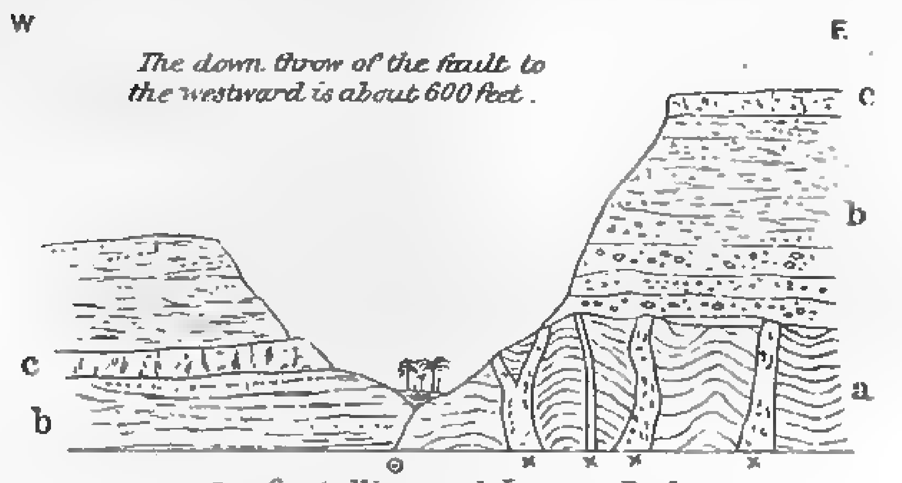


Fig. 5. SECTION OF WADY NASB AT THE SPRINGS.



a. Crystalline and Igneous Rocks.
b. New Red Sandstone.
c. Limestone with Iron and Maganese.
× Dykes.
⊙ Fault

Fig 1. SKETCH SECTION SHOWING ARRANGEMENT OF SUPERFICIAL DEPOSITS ON THE DESERT NEAR MOSES' WELLS.

a. Tertiary escarpment
b. Conglomerate Gravel Hills
c. Blown sand ridges
d. Moses' Wells.
e. High water Line

Fig 2 SECTION ALONG THE CLIFFS FROM WADY GHARANDEL TO HAMMAM FARAOUN.

a. Great Gypseous series
b. Flint conglomerate series Miocene
c. Asphaltic white Limestone with flints
d. Crystalline
e. Terraced Flint Gravels

Fig. 3. CLIFF SECTION NEAR THE MOUTH OF WADY TAIBE.

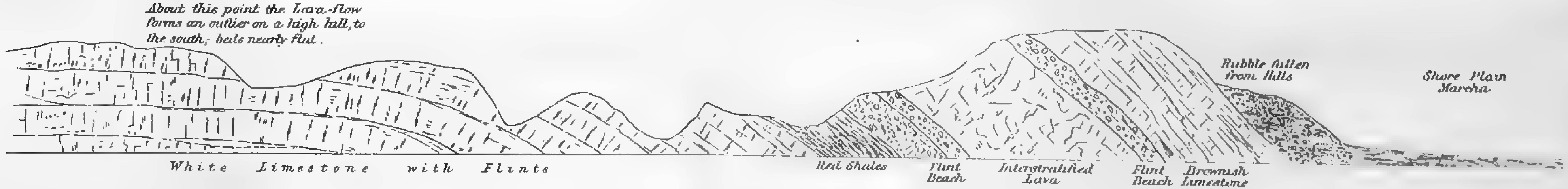


Fig. 4. SKETCH SECTION FROM JEBEL TIH TO THE GHARABI ESCARPMENT (along the line marked in the Sketch Map)

General direction North and South.

F. Dangerfield, lith. 22 Bedford St. Covent Garden.

H Bauerman Del

of similar fascioles in different genera might be explained in the opposite way to that which the author adopted, and that they might be considered evidence of genetic connexion, subsequent variations having produced differences of generic value.

Mr. Gwyn Jeffreys also considered that every palæontologist ought to be a naturalist, as the fossil and recent forms are intimately connected by insensible gradations. All the *Echinocardia* with which he was acquainted were inhabitants of clean sand.

Dr. Duncan, in reply, stated that if the Spatangidæ were classified, generic distinctions would be observed quite irrespective of the presence of fascioles. He considered the fascioles, like the horns of Mammalia, of third-rate structural importance. One specimen from Arabia appeared to have a fasciole developing. He remarked that all the fossils were of the same size, so that it was impossible to determine whether the formation of fascioles was dependent on embryonic conditions, or whether they were developed in the perfect animal.

December 9th, 1868.

Arthur Champernowne, Esq., M.A., Dartington Hall, Totnes, Devon; James Thomson, Esq., Glasgow; W. Chandler Roberts, Esq., F.C.S., Associate of the Royal School of Mines, Thurlow Place, Dulwich; John S. Winbott, Esq., M.A., Sandridge Vicarage, St. Albans; Lawrence Preston, Esq., Keynshambury House, Cheltenham; John H. Blake, Esq., Geological Survey of England and Wales, 9 Aberdeen Park, Highbury, N.; John Hewitt Wheatley, Esq., Abbey View, Sligo; Owen Rees, Esq., 26 Albemarle Street, W., and Octavius Russell Fabian, Esq., 5 Bruce Terrace, Lordship Lane, Tottenham, were elected Fellows.

The following communications were read:—

1. *Note on a* Geological Reconnaissance *made in* Arabia Petræa *in the Spring of* 1868. By H. Bauerman, Esq., F.G.S., Assoc. Roy. School of Mines.

[Plate I.]

The following communication is of an essentially unsystematic nature. Owing to the small amount of country traversed, it has not been possible to construct anything more than a single line of section, which it is believed will be more acceptable as a contribution to exact Geology than an attempt to frame a general geological map of the whole country from observations made at only a few points. The order followed is, therefore, that in which the sections were observed, making it, as the title implies, more of a geological itinerary than a systematic description.

The country included in the description is that between Suez and the lower part of Wady Ferran, the crystalline rocks of Sinai and the Tertiary beds near Túr being reserved for another communication, as I have not sufficient time at command to describe them in the present paper.

General Outline.—As regards its physical outline, the western side of the peninsula of Arabia Petræa, or that part of it under immediate consideration, between Suez on the north and Túr on the south, along the coast of the Red Sea, together with the high ground behind, up to the culminating point of the country on the ridge of Sinai, may be best described as forming a series of comparatively level masses, arranged in steps or table-lands varying in height according to their distance from the coast. Through these steps have been cut a number of valleys, comparatively deep and of tortuous course, the general level of the plains being broken by numerous peaks, formed either by outlying masses of sedimentary strata or the undenuded edges of dykes of intrusive rocks, which have resisted the action of the atmosphere more than the softer granite and crystalline schists containing them.

Desert near Suez.—The country from Suez southward to the mouth of Wady Gharandel, a distance of 40 miles, as a rule, slopes gently down to the sea, though in some places an old raised beach forms a cliff from 10 to 25 feet in height. At Moses's Wells (Ain Mousa), about seven miles below Suez, the beach is very flat, so that boats cannot come within a considerable distance of the shore. The surface of the ground is strewed with marine shells and corals, often cemented into a kind of shelly oolite (miliolite). This recently formed rock is common along both sides of the Gulf of Suez, and often contains full-sized specimens of *Tridacna gigantea* with the nacre still fresh. At Suez, just opposite the hotel at the landing-place for boats, on the Arabian side, so much of it is found that the excavations for the Suez Canal are made by boring and blasting with gunpowder.

Raised Beach.—Immediately on getting above the level of high-water-mark, a change is seen in the shells, which are decidedly less fresh in lustre and appearance, although not sensibly worn or broken, and occurring in large quantities. The worn and broken appearance becomes more marked on receding from the beach; and at the same time the character of the sand changes. The proportion of foraminiferal shells and rolled grains of shell-sand diminish by the admixture of grains of quartz and other comminuted rocks derived from the waste of the interior cliff, until at about two miles from the shore, and about 40 or 50 feet above high-water-mark, the former have almost entirely disappeared. The subsoil at Moses's Wells consists of soft shales and gypseous marls, which extend across the bay to Suez. They are of marine origin, or at any rate have been below water, as in a section on the Suez and Cairo Railway, about half a mile from the town, they are seen to be covered by the raised shell-beach before mentioned.

Desert at Moses's Wells.—The general relation of the superficial deposits near the head of the Gulf of Suez is shown in Pl. I. fig. 1: *a* is the escarpment of the Tertiary rocks, probably some part of the Nummulitic series. From the foot of the cliff to *c* the ground is covered with small table-topped hills and ridges, formed of a limestone-gravel cemented into a conglomerate by means of gypsum, and about

4 feet in thickness. This is sufficiently hard to resist the action of the weather, and, to a certain extent, it protects the softer gypseous marls and shales underneath. As the waste of the latter still goes on, the blocks of conglomerate gradually lose their support and fall down, leaving a conical hill, which is then rapidly destroyed, unless a fresh conglomerate is formed in place, as frequently happens, owing to the ready solubility of the cementing material—gypsum. In some places the gravel is from 15 to 20 feet thick; but it sometimes happens that the pebbles disappear, leaving a bed of almost pure crystalline gypsum in its place. The pebbles in the conglomerate are almost all of Nummulitic limestone, of a dark-grey, black, or yellowish tint, and externally present the peculiar pitted and furrowed appearance caused by the scouring of drifted sand, which is so characteristic of all the loose stones found on the African and Arabian deserts. At *c* there is a low terrace of blown sand; and from this point to the shore worn shells and branches of coral abound, increasing in quantity towards the beach. From *c* to the foot of the hill they are almost entirely absent, only a single valve of a *Pecten* having been found between the former point and the region of the conglomerate-hills.

The springs at Ain Mousa rise from the salt and gypseous shales, probably being fed by the drainage of the gravel-region at the back of them. There are 10 or 11 principal ones. The largest discharges into a basin about 30 feet in diameter, and shows a slight discharge of gas. There is a small deposit of bog-iron-ore in the basin, and, according to Heuglin, a great number of Diatomaceæ are found in the mud. An upper spring, about 150 yards to the south of the gardens, crowned by a solitary palm tree, which forms a prominent and welcome land-mark to the traveller returning from the desert towards Suez, contains a great number of *Cyprides* also, which, together with the sand, form a basin round the point of discharge.

The height of Moses's Wells above high-water-mark is about 45 feet. Their aspect has changed considerably since the time of Heuglin's visit in 1861, when it appears to have been a place of residence for Suez merchants, as he speaks of having lodged in the villa of the Belgian consular agent. Nowadays there is nothing approaching to a decent habitation, although the enclosures have increased in number, the most pretentious being a miserable grog-shop rejoicing in the name of the Hotel de Bourgogne. The springs are now nearly all enclosed, even the higher outlying one on the hill having been in process of enclosure by a wire fence on our return in the month of June last (1868). At the same time it is also subjected to the incursions of visitors to a much greater extent than formerly, owing, no doubt, to the great influx of population at Suez and other points on the Isthmus, consequent on the undertaking of the canal from the Mediterranean to the Red Sea, and the new deep-water harbour for the Indian mail-steamers. A certain amount of rest must, however, have been given to the place since the cessation of the water-supply to Suez, which town, it need scarcely be said, is no longer dependent upon the salt and bitter waters of Ain Mousa and a group of similar springs in the valley of the isthmus, which formerly supplied it, but receives good fresh water from the Nile by means of the so-called *sweet*-water canal—a work probably of greater importance and significance to the wellbeing of the country and of the transit-trade than the more pretentious, but still unfinished, maritime canal, from which such great results are expected by its spirited promoters.

Moses's Wells to Wady Amara.—From Ain Mousa to the southward for about 25 or 30 miles the desert presents the same general features as those last described, a gently swelling or terraced plain of sands and gravel, several miles broad, occupying the whole of the tract between the sea and the rise of the hills. The ground is covered with stunted bushy plants, affording a tolerable amount of feed for the camels during the spring time, and as long as any water from the winter rains remains in the pools formed on the damp retentive ground, where the gypseous shales and clays are close to the surface; but later, or during the summer and autumn months, the whole becomes parched up and horribly barren and desolate. Sand-scored stones are abundant everywhere. Their prevalence is to be accounted for by the ceaseless activity of the sand-drift, as, even when the air is apparently calm and still, there will generally be enough wind moving to set the sand in motion on the ground and a few inches above it. As a rule, the hardest rocks are the best polished,—this being more especially the case with quartz, jasper, carnelian, and similar siliceous substances; while the limestones, in addition to being polished, are furrowed and scored in every direction, and their surfaces studded with numberless small reticulating grooves, resembling the hill-shading on a topographical map. Occasionally masses or portions of crystals of calcite are found, which, under the same influence, have been etched in a manner in many respects similar to that produced by the action of a liquid solvent; and the crystals show a tendency to decrement along the principal directions of cleavage. Many of the limestone-pebbles are also blackened in a peculiar manner, probably by some cryptogamic or other low form of vegetable life.

The plain of the desert is broken through by the numerous channels which convey the water of the main valleys to the sea; but these are so small and slightly marked that they might easily be overlooked by travellers passing through the country in the summer time, when the upper watercourses are quite dry, only the recently dried and partially cracked muddy surfaces in places showing signs of where the last water had been licked up by the fiery atmosphere of the desert. In the winter time, however, a sudden heavy rainfall in the hills occasionally sends such a flood of water rolling down that the whole plain in the neighbourhood of the Wady is turned for the time into a lake; and, according to the statements of the Arabs, camel-trains have occasionally been delayed for many days, until the flood has subsided; and men have actually been drowned when suddenly overtaken by the waters in the low ground. The wormwoodbushes recall strikingly the sage-barrens of the desert in the Columbia Valley on the west side of America.

The hills along the northern portion of the desert present no particular features of interest, but form a long and tolerably uniform line of escarpment, not unlike that of the English Oolites or other flat-bedded limestones, and are probably not more than 300 or 400 feet in height. The only marked point is that known as Gebel Sudder, called in addition, on the Admiralty chart, Barn Hill, which rises above the entrance of Wady Sudder.

The hills in the middle distance are those of the gravel-topped alluvium already mentioned as occurring in the same position behind Moses's Wells.

Along the gravel-plain many detached crystals of gypsum, of small size, are met with. They are tolerably perfect, and of the compound arrow-head type, but usually opake in places. This may be due either to exfoliation, attended probably with a partial dehydration, or to a molecular change alone.

Near Wady Amara the raised beach is accompanied by patches of a kind of oolite, made up apparently of rolled fragments of shells, and consolidated into an extremely hard conglomerate, with a decided dip towards the sea. These beds are peculiarly interesting, as bearing on the distribution of organic remains in limestones, and appear to explain why fossils are found so irregularly in different quarries in the same bed. In this case it is evident that the shells imbedded in these consolidated deposits have a much better chance of being preserved than those that are lying about exposed to the air and the sand in the unconsolidated beach all around them. The consolidation is probably due to the joint action of the air and the sea-water; and it is owing to the latter agent that the deposit has a seaward dip. In future times, after submergence and upheaval, these coarse shelly oolitic patches will most likely appear as lenticular or false-bedded masses in a more compact limestone. The consolidated beaches, with *Tridacna gigantea*, recall forcibly to the mind of the observer the *Calcaire grossier* of France.

Alabaster Series.—Approaching Wady Gharandel from the north, the ground becomes more broken as the hills come nearer the sea, and a line of cliff is formed by blue shaly clays, weathering to a rusty brown, filled with nodules and irregularly bedded masses of gypsum, both in the form of selenite and dull granular alabaster. The tumbled surface of the marls has been repeatedly rearranged by the formation of fresh masses of gypsum, deposited from solution in the same manner as already noticed in describing the marls near Moses's Wells, but on a much larger scale.

The gypseous series is underlain by calcareous strata at the mouth of Wady Gharandel, but extends for a considerable distance up the valley.

Wady Taragi.—About two miles to the north and a little to the eastward of this point, there is a remarkable section in a small valley called by the Bedaween Wady Taragi. This is about 200 feet deep, and in places more, with a breadth at the bottom of only

15 feet; it is entirely excavated in granular massive gypsum or alabaster, veined with blue and grey stripes and occasional patches of clay, the whole being apparently a solid mass. The watercourse was nearly dry on the 9th of April, only a few of the pools below the places where there are small waterfalls in flood-time being filled with small quantities of intensely salt and bitter water, so that it could be easily followed on foot. We traced it up for about $1\frac{1}{2}$ miles, making a very tortuous course, when the cliffs appeared to be getting somewhat lower; but there was no sign of the gully coming to an end as far as could be seen from the highest point reached. The bottom of the valley is eroded into a smooth and nearly semicircular channel by the rush of the winter torrents, either in the solid rock or in large tumbled blocks; while, just above the flood-level, the side cliffs are scored into parallel grooves resembling the fluting of an Ionic pilaster, by the action of water charged with sand trickling down from above. These grooves are about half an inch deep, separated from each other by small sharp-edged ridges. They are, as a rule, vertical, and in the direction of the flow of the water; and they always end, in the most striking manner, just at the high-water-line.

At intervals all along the valley an old alluvium of gravel and sand with fragments of gypsum, the last being exceedingly rough and irregular in outline, is seen at heights of between 50 and 70 feet. This gravel has been eroded into steep cliffs. The alabaster occurring in this valley somewhat resembles that of Chellaston and Fauld, in Staffordshire, but without the red veins, being only mottled with blue or grey bands of clay instead. The best blocks seen, lying loose on the watercourse and tumbled from the cliffs, cubed about 4 feet on the side; but it would be difficult to find one of this size perfectly sound, though there are many places where large masses might be got by quarrying. The semitranslucent variety of alabaster, such as that of Volterra, does not occur here; but nodules of a somewhat similar character were observed in the dark shales further to the north.

Gypsum of Gharandel.—In the lower part of Wady Gharandel the same gypsum-marls appear, in hills of considerable height, say from 300 to 400 feet. The principal feature is formed by a massive bed of opake-white gypsum, overlying dark bluish-green and gray marls and clays filled with selenite in fibrous masses, and occasionally in detached crystals. The large bed breaks up and falls, from the slipping away of the marl below it; but the tumbled blocks are mostly reconsolidated by the action of water, forming reconstructed beds on the slopes of the shales, which are again subjected to denudation, giving rise to hills of extremely irregular outline and structure. The whole of the surface of the slopes, especially the more prominent, is very rough and uneven, owing to the solvent action of atmospheric water on the gypsum. The more impure and sandy portions, which resist the weather better, form regular saw-backed crestings, so that the process of climbing the hills, in spite of their being mainly made up of clay, is disagreeably like going along a garden-wall liberally finished off with broken bottles. As in the case of Wady Taragi, the terraced alluvium of the valley is mainly made up of fragments of gypsum; and these are often formed into inclined planes by the slipping of the marls below.

Gharandel (see Pl. I. fig. 2).—The lower end of Wady Gharandel, where the valley proper abuts upon the alluvial plain of gravel and sand extending about a mile from the beach inland, is about 60 or 80 feet wide, between cliffs of a calcareous grit-stone, finely and regularly stratified, that comes out from underneath the gypsum-marls, which dip to the north at an angle of about 20 degrees. These beds are not very fossiliferous: only a few small *Nautili*, a *Pecten*, a small *Turritella*, two or three single valves of Brachiopods, and a *Serpula* were found; and these required to be chiselled off the faces of the slabs in order to detach them from the rock. On the south side of the valley they form a tolerably high and steep cliff with a flat top, covered with coarse flint-gravel. South of this point, going towards Hammam Faraoun, the escarpment is lower, and frequently cut back on to dry valleys, with many detached pinnacles and square outliers of limestone of a white chalky character, nearly horizontal, and with a few layers of flint near the bottom. When broken, the white limestones are often found to be extremely bituminous; and in a small dry valley about a mile south of Wady Gharandel, a thin layer of bitumen similar to that of the Dead Sea was found included in a fallen block. Much of the lower part of the limestone is of a snuff-brown colour, from the amount of bitumen contained, forming a material similar to the Seyssel asphalt-rock, employed for making pavements in England and on the continent of Europe.

The same order of things continues for about three miles: low ridges of soft limestone, which are often hidden for a considerable distance by the terraced gravels and alluvium of the valley called Wady Hussied, gradually approach the shore until they are succeeded by the great cliff of Bukel el Faroun, which rises from the sea to a height of about 1500 feet. This is made up of a bluish-grey or white crystalline limestone, not very distinctly stratified, but enough so to be seen dipping, at an angle of about 20 or 25 degrees, towards the north, a direction which would make it pass under the bituminous bed; and this is most probably the case, although the exact junction is not seen, owing to the great spread of the superficial deposits of Wady Hussied. However this may be, there is no doubt of the occurrence of Nummulites both in the upper white and bituminous beds and in the more crystalline limestone below; and the same fossils were found some distance beyond the point where the springs rise. But for this there would be considerable difficulty in assigning the lower beds to their proper horizon, as they are very much unlike the Nummulitic rocks of Egypt, being of a crystalline or semi-metamorphic character. Their resemblance to the rocks of the Wady Araba, on the opposite side of the Red Sea, has led Dr. Figari Bey to regard them as belonging to the Oolitic period; but I have been unable to concur in this view, owing to the presence of the fossils. The apparent metamorphic character of the rock is further increased by the presence of small veins of sulphur, associated with a white granular gypsum.

Pharaoh's Baths.—The hot springs known as Pharaoh's Baths rise partly out of the rock at the foot of the cliff close to the sea, or out of the sand of the beach. The two principal springs are the hottest, with a temperature, according to Figari Bey, of about 160° Fahrenheit, in April 1847, and, according to Russegger, of 157° in October 1838; and it probably still remains the same, although I was unable to ascertain this exactly, having only a comparatively short-scale thermometer, which could not be freely exposed to the action of the water without running the risk of bursting it. As it was, the mercury went up to 148 degrees immediately; and this was the highest point that it was safe to try. The water is clear, with a slight hepatic odour, although no sulphuretted hydrogen could be found by the ordinary tests. It is probably only slightly saline and bitter, like that of all the springs in the lower part of the country near the shore covered by Secondary and Tertiary strata.

Bituminous Limestone.—The white and bituminous limestones cover a considerable tract of country southward and eastward from Hammam Faraoun. The upper flint-conglomerates are seen again, probably as outlying patches, on the summit of a low hill in Wady Atal, where they rise to about 750 or 800 feet above the sea-level—a position that corresponds approximately with the supposed Pliocene beach-line in Figari Bey's map. Lithologically they consist of finely conglomeratic calcareous sandstones, with pectens, and a softer bed full of large oysters, mostly in fragments. These are very similar to the upper brown Tertiary beds overlying the great Nummulitic series at Cairo. The great plain known as the Marcha, north of the mouth of Wady Ferran, is bounded by a continuous escarpment of the white beds, which in places contain sufficient salt to be considered worth working by the Arabs, although no great quantity can be obtained, the mineral occurring in strings and patches in marly beds, not more than an inch or two inches in thickness at most. It is probably from these rocks that the beautifully fibrous and contorted specimens often seen in cabinets, and marked as coming from Arabia, are obtained, as the same structure is very common at the locality in question, which is known as El Laggam, and is near the valley of the same name.

Another good section, illustrating the relative position of the white limestone and the flint-conglomerates, is to be seen in the lower part of Wady Taibe, where there seems to be a considerable local disturbance of the upper beds. The white beds are nearly flat in the valley about two miles up; but nearer the shore they roll under a series of red conglomerates and grey calcareous sandstones, full of partially rolled fragments of flints of all sizes, with a few pieces of *Pecten*, dipping seawards at about 25 degrees. A bed of black doleritic lava is interstratified between two of the coarse conglomerates; and an outlier of the same rock occurs at a higher level further inland, where the beds are flatter. As far, therefore, as can be made out by these instances, the igneous rock is not an intrusive mass, but an old lava-flow which was poured out in shallow water during the formation of the flint-conglomerate. The general section at this place is shown in Pl. I. fig. 3. The outer horizontally arranged beds, consisting of the rubbish and detritus of the hills, form a roughly terraced cliff above the plain of the Marcha, which latter is most likely formed of sand and gypseous marl, like those of Suez and of Moses's Wells.

Sarabut e Gamnal—Flint-conglomerate.—In the higher parts of Wady Atal, Gharandel, and the other valleys cut through the tableland of the white limestone, the sections are much obscured by the accumulation of alluvial gravels, which increase in quantity towards the interior of the country; and as the valleys are broad, with comparatively low cliffs, drifted sand also accumulates in considerable quantities in places. On reaching the high ridge known as Sarabut e Gamnal, which covers the pass leading into the sandy plain of Ramleh, there is a great change in the character of the beds—an enormous quantity of coarse flint-conglomerate and white limestone forming the crest of the hill on either side. These, no doubt, belong to the same set of beds as the rocks at the mouth of Wady Gharandel and Wady Taibe, although developed on a greater scale; and, judging from the size of the pebbles, they have probably been deposited in shallower water than the same beds further westward. A fault with a westerly downthrow crosses the ridge of Sarabut e Gamnal, throwing the flint-conglomerate against the dark-red or brown Triassic sandstones below. This dislocation, either alone or with a system of parallel fractures, is continuous for many miles in a north and south line, and has a marked effect on the physical geography of the country; for by it the soft white and bituminous series of beds in the region already described are cut off, as by a wall, from the older rocks of the interior.

Ramleh (see Pl. I. fig. 4).—The plain of Ramleh, about 1750 feet above the sea-level in the centre, and about ten or twelve miles broad from north to south, is covered with drifted and blown sand, resting on red and brown quartzose sandstones and conglomerates, the beds being nearly flat, or forming a slight anticlinal arch. On the northern side it is bounded by the great escarpment known as Jebel el Tih, which forms the edge of the Cretaceous and Tertiary plateau extending northward to El Arish and Palestine. The southern edge is deeply indented with many narrow and winding valleys, which are cut down to the crystalline rocks below, and which unite with like valleys coming from the south, from the main-drainage line of the district in Wady Baba.

Tih Escarpment.—As regards the escarpment of Tih I have but little information to give, as it lies beyond the district where I was more immediately at work. For the following section I am indebted to my friend and associate Dr. C. Le Neve Foster, who made a flying visit from our camp in Wady Suoug:—

Section (in ascending order) of the Escarpment of Tih, starting from the Plain of Ramleh.

		feet.
	White, reddish, and purplish sandstones	300
A.	Shaly beds	50
B.	Coarsely bedded sandstone	20
C.	Shales and sandy shales, with gypsum and some thin nodular limestones near the top	100
D.	Hard, compact cream-coloured limestone	12
E.	Hard limestone and shales, with a rubbly bed containing hippurites; ferruginous sandy bed at top	100
F.	Limestone and shales, with large Ammonites	100
G.	Calcareous sandstone, with large nodules of alabaster	50
H.	Tumbled stuff	40
K.	Compact limestone, about	20
L.	Tumbled stuff	50
M.	Limestones and marl, some chloritic and some with flint nodules; a hard bed near the top	100
	Total (A to M)	642

The above total (A to M) may be regarded as an approximation to the thickness of the Lower Cretaceous rocks, the 300 feet beneath being assigned to the Trias, as will be shown further on. Fragments of several large Ammonites were found, mostly in a bad state from exposure to the weather, and too cumbrous to bring away; so that only pieces of sufficient size to show the nature of the form and the pattern of the chambers were collected.

On the top of the escarpment the beds form a broad plateau, falling with the dip to the northward, and far away in the distance crowned by an escarpment of white beds, probably the representatives of the Gharandel and Taibe bituminous series. The highest point of the Tih plateau is 4630 feet above the sea-level, according to Russegger.

From the plain of Ramleh there is a descent of about 250 feet into Wady Baba, immediately to the south of which is the old mining-region. This comprises, within an area of about twenty square miles, the copper-smelting station of Nasb, the old copper-mines of Wady Chaly, the quarries and temple of Sarabut el Khadem, and the turquoise-mines of Wady Maghara, forming by far the most interesting district, from an antiquarian and geological point of view, in the whole of the Sinaitic peninsula.

Nasb.—In the cliff at the lower end of the Nasb valley, on the right-hand or western side, the red-sandstone series of Ramleh is seen to rest unconformably on a dark-green schistose gneiss and mica-schist, pierced by a great number of intrusive dykes, principally porphyries, with small oligoclase crystals in a dark-red or black base. The lower member of the series is a dark-red, soft sandstone, with marly partings; it is very similar in character and general appearance to the Lower New Red Sandstone about Chester, and may be from 100 to 200 feet thick. This is succeeded by lighter-coloured rocks of a similar character, much false-bedded, and variegated with yellowish, brown, red, and purple bands, making a thickness of about

350 to 400 feet more. The top of the hill is capped by a thin limestone, from 8 to 15 feet in thickness, which is tolerably persistent on the northern side of the district. It is usually grey or light brown, very crystalline, and at times much resembling spathic iron-ore. It contains a few obscure fossils, chiefly encrinite stems and rings, with a few imperfect sections of cups; and, according to Mr. Etheridge, these are to be referred to Triassic forms. Mr. Salter, on the other hand, states that they are Carboniferous, including forms of the genera *Rhodocrinus* and *Poteriocrinus*, and that they are associated with the spiral univalves *Murchisonia* and possibly *Eulima*.

The thin limestone-beds are covered by other sandstones similarly false-bedded to those below, but of a lighter colour, and they form the highest rocks in the Nasb district; but further south, in Wady Nagb el Bedra, they are succeeded by beds of Cretaceous age.

Age of the Sandstone.—The same series of sandstones has been described by other geologists as occurring in Egypt and Nubia under similar conditions, *i. e.* between older crystalline schists below and undoubted Cretaceous beds above. Russegger calls it "Nubian Sandstone," colouring and describing it as Lower Cretaceous in his maps of Egypt, Nubia, and Arabia Petræa. The text, however (Reisen, vol. ii. pt. 1. p. 570), contains no positive statement to the above effect, but only says that the beds in question are not younger than the Lower-Cretaceous period.

Figari Bey describes the tripartite arrangement of the series (two great masses of sandstone, with a thin limestone between them) as occurring in Egypt, Sinai, and in the neighbourhood of Akaba; and in the latter place he states the total thickness to be about 850 feet *. He assigns the whole to the Trias, taking the limestone as representing the Muschelkalk, although the evidence for this determination (other than lithological character) is not very clear. The only fossil mentioned is a good-sized *Ammonite*, not named specifically, but said to approximate in character to a Triassic form †. I have conformed to this view, without, however, wishing to express any very decided opinion on the subject, owing to the great want of evidence.

Manganese-bed of Nasb.—The thin limestones capping the hill are, on the western side of Wady Nasb, thrown down to the bed of the watercourse by a fault running nearly north and south. On both sides they are commonly associated with ores of iron and manganese, which run in a nearly continuous bed of varying thickness, as a chain of pockets or lenticular deposits, over the greater part of the district. The mineral usually consists of a compact brown hæmatite, passing, by admixture of quartz, into an iron-jasper or extremely ferruginous sandstone. Some of the larger beds, which are from 5 to 8 feet thick, contain compact and mammillated brown hæmatite in large masses, with small, but beautifully transparent, crystals of göthite in the hollows. Pyrolusite is also found in considerable quantities in places, usually in large nodular masses, enclosed in the iron-ore and associated with psilomelane. The base of the cliff, throughout

* Studii scientifici sull' Egitto e sue adjacenze, tom. ii. p. 550.
† *Ibid.* tom. i. p. 146.

the entire length of the Nasb valley, is strewn with masses of a hard black hæmatite, in angular blocks with sand-scratched surfaces, having a somewhat scoriaceous look. This appears to have been confused by travellers at different times with the actual copper-slags that exist in the same valley. Blue and green carbonate of copper, and a little calamine, are also found in the sandstones on the same horizon.

Old Mines.—Several small pits have been opened upon the iron and manganese bed, both at Nasb and on the top of the adjoining table-land. As far as can be made out from Arab accounts, none of these are of any great age, the most important dating from about sixty years back. Several camel-loads of pyrolusite are said to have been taken from a pit on the hill, and sent to Cairo as an experiment, the general belief being that it was sold for use in colouring the eyelids (kohll) instead of galena. If this was the purpose to which it was really applied, we can easily understand why the experiment was never repeated. On the western side of the Nasb Valley there are indications of old workings, besides modern levels driven a short distance into the side of the hill; but their exact nature is not quite clear, as they have become choked up with rubbish, partly from the fall of the roof, but more from the sand and wash of the valley brought down by the rains.

At Wady Khalig, a tributary of Wady Baba, about four miles below Nasb, the iron and manganese bed has been extensively excavated by the old miners. Here it occurs under the form of a soft schistose white marl, variegated with green and red patches, and contains small strings of earthy-brown iron-ore, with a little blue and green carbonate of copper, and the smallest possible spots of copper-glance or perhaps indigo copper-ore. The old workings extend about 120 yards along the face of the hill. Near the surface the roof has fallen in many places, leaving a large irregular cavern, with several openings to the day. Deeper under the hill, where the rock has been better protected from the weather, the height of the excavation is about 5 feet, and the whole of the ground has been removed, with the exception of a few small pillars at distances of about 50 feet apart. The walls and pillars are covered with small chisel- or gad-marks, apparently made with a tool about $\frac{3}{4}$ or $\frac{7}{8}$ of an inch in breadth. The distance to which the workings extend from the face of the hill is about 40 yards; but this cannot be determined exactly, as there is a considerable deposit of muddy sand on the floor, washed in by the rains (the bed having been followed on the dip), which has no doubt completely filled up the lowest part of the mine. In some places the roof is supported by stone and mortar walls; but these are probably of newer date, having been put up to render the cavern secure for the purpose of a dwelling or a store-house.

There are no inscriptions or any other guide to the probable date of these workings; but it is evident, from the extraordinarily poor character of the ore, that they must belong to a very early period, when metals were of nearly uniform value, owing to their production being confined to a few localities. Judging by the present conditions of mining economy, it may be fairly said that no such deposit could possibly be worked now unless the value of copper was to be raised to several times that of gold. On the other hand, it may be said that the ground worked away by the ancients was possibly richer than that which has been left; but there does not appear to be much reason for such a supposition, as it is evident from the nature of the excavations that the rock has been searched with extraordinary diligence: numerous small cavities in the walls show that even the smallest nodules of ore have been removed wherever there was a chance of doing so without breaking down a quantity of dead rock. So perfectly has nearly every visible spot of ore been removed, that we were for some time in doubt as to whether the outer hollow was really an old mine and not a natural cavern.

Copper-works of Nasb.—The ores from the mine at Wady Khalig were smelted in Wady Nasb, close to the springs, as is evidenced by the mass of slags, which forms a roughly elliptical heap about 350 yards in length and 200 in breadth. The depth is very variable, and probably not more than 8 or 10 feet at the most; and over the greater part of the area the slags form only a thin covering to the rock. Upon digging into the heaps, numerous clay twyer-nozzles, with an air-passage of about $\frac{3}{4}$ inch diameter, were found. These have evidently been formed by the accretion of the slag to the wall of the furnace in front of the blast, and in many cases have been repaired by plastering fresh clay over the former face—an operation that is seen, from some of the broken twyers, to have been repeated three or four times. In one instance the slag nose has accumulated to such an extent as almost completely to block up the passage for the blast. In nearly all cases shots of metallic copper are found included in the slag adhering to the twyers; but not a fragment of unaltered ore, or of any kind of regulus, was found, although carefully looked for. The only building that can be regarded as having formed part of a furnace is a pair of small walled enclosures of unequal size, the larger one being about 6 feet square, and the other $2\frac{1}{2}$ feet square, both being walled in on three sides to a height of about 2 feet above the ground. These may possibly have been the outer walls of a hearth or low blast-furnace; but no trace of any lining that had been subjected to the action of heat could be detected. In the smaller compartment a stone pestle, worked round, and about $1\frac{1}{2}$ inches in diameter, was found.

On examining the different parts of the heap, it becomes evident, from the nature of the slags themselves, that several different operations were carried on here. Thus in places the fragments are broken up small, and contain many shots of metal now mostly changed into malachite; these are probably rich selected cinders, either from the first fusion, or perhaps from the refinery, which have been put on one side for further treatment; while, on the other hand, at the upper end of the heap, crusts of well-melted clean slags, from $1\frac{1}{2}$ to 2 inches in thickness, are spread over the ground, as though they had been allowed to flow from the furnace and solidify upon the rock in the place where they are now found. It may well be, therefore, that these represent the operations of larger furnaces, worked perhaps at a later period, when the art of metallurgy was further advanced than was the case when the thinner and less perfectly melted slags were produced.

At the lower end of the Nasb valley there is another slag-heap, of smaller extent, but in other respects similar to that at the springs. A third was found in Wady Gharandel, upon a terrace of Nummulitic or Cretaceous limestone, far away from any place producing copper-ores, but near water, proving that the sites for smelting-works were determined chiefly by the presence of springs, where there is usually some quantity of wood, even at the present time. The charcoal used for smelting appears to have been derived from the *Acacia vera*, which still flourishes round the springs; and though of late years the wood has been much cut down, in order to produce charcoal for the supply of Suez and Cairo, many of the trees are of very great antiquity.

I was unable to find any traces of the ruins of large calcining furnaces, and basins that had probably served as stamps and catch-pits, as described by Dr. Figari Bey*. Probably these are only naturally jointed piles of stone, produced by the action of the weather on the sandstone, which breaks up into very regularly shaped masses. It cannot be supposed that the ancient Egyptians were in the habit of subjecting their ores to any complex mechanical treatment, still less to the process of stamping and washing, especially as, according to Haupt, the use of stamps was not introduced in mining until the 16th century.

Nasb Fault (see Pl. I. fig. 5)—*Sandstone Outliers.*—The fault running through the Nasb valley has a westerly downthrow of about 600 feet. A second fault of the same kind, nearly parallel, and with a downthrow in the same direction, traverses the next higher valley, known as Wady Lechian, where the lower crystalline schists, studded with numerous intrusive dykes, come to the surface and form a very rough ridge about 500 feet in height, above which the red-sandstone series occurs in the usual order, attaining a height of about 1000 feet more in the peak of Om Riglaine, which is really a great outlier of nearly horizontal sandstone upon the plateau of crystalline rocks, the summit being a narrow ridge of about 30 or 40 yards in length and about 3600 feet above the sea-level (3609 feet by barometrical determination). Several other outliers of the same character, but rising to greater heights, are seen from the top of Om Riglaine, the most important being a twin peak close by and two great masses to the eastward, which do not appear to have any special name other than Gharabi, which is applied by the Arabs as a kind of generic term to all mountains that are not endowed with names derived from poetical or legendary sources. In Wady Suoug, or Saaou, to the south-east of Nasb, the crystalline schists are continuously exposed at the bottom of the cliff, the upper sandstone being cut up into a number of tributary valleys. On the northern side, however, the

* *Op. cit.* vol. ii. p. 647.

plain of Ramleh continues, and, near the bend of Wady Saaou, forms a square edge, so that the drifted sand of the plain pours down like water over a weir, and forms great heaps on either side.

Sarabut el Khadem, Wady Chamilé, &c. (see Pl. I. fig. 4).—The ruins of Sarabut el Khadem are on the high sandstone-plateau, 2290 feet above the sea-level. There are ten sculptured stones upright, which are, I am informed, of the period of the 18th Dynasty. Below the temple or necropolis, whichever it may be, are two small quarries in the red sandstone, whence have been derived the blocks upon which the hieroglyphics were sculptured. Great numbers of flint flakes are found all over the plateau and in the quarries, where they are associated with stone hammers of a double conchoidal form. The iron and manganese bed crops out at the top of the hill, overlying some shaly beds containing a little green carbonate of copper, probably the same as those seen in the mine at Wady Khalig. The limestone-beds are also seen capping many of the smaller hills on the plateau. About 15 feet below the limestone, turquoises are found in a bed of ferruginous sandstone, which has been followed to a certain extent in two caves of ancient date, as evidenced by the hieroglyphics near the entrance. The workings are still kept up in a small way by the Bedaween. The turquoises occur principally in the joints traversing the sandstone, and are apparently rare and small, though of good colour.

From Sarabut el Khadem Wady Saaou runs in a south-easterly direction for about four miles to the height of land which divides it from Wady Chamilé. The valley is about $\frac{1}{2}$ or $\frac{3}{4}$ of a mile broad, with alluvial terraces covered in part with blown sand. The cliffs are everywhere formed by New Red Sandstone above gneissic rocks, and on the right-hand side (going up) they rise to a considerable height, probably exceeding 4000 feet in the peak of Gharabi already mentioned. This, together with many of the neighbouring hills, is capped by a thick bed of markedly columnar lava. Close to the top of the pass, which is 2100 feet above the sea-level, the same rock breaks through the soft sandstones, and forms a dyke about 50 feet thick. Here it is much decomposed, forming earthy spheroidal masses, the original character of which can scarcely be made out by inspection. Dykes of a very similar kind are found in the valley going up to the plain of Ramleh on the north. The course of these dykes is about south-east, or parallel to the direction of the valleys.

After crossing into Wady Chamilé, which also runs in a south-easterly direction, the sandstones become softer, the valley widens, and is fairly well covered with grass and scrubby bushes. This continues for about three or four miles, when the sedimentary rocks come to an end, only a few small and scattered outliers being visible on the tops of the gneissic hills. About this point the valley turns round to the south-west, and becomes narrow and very tortuous between steep wall-like cliffs of granite, with many hard red porphyritic dykes. Although perfectly dry in the summer months, there is abundant evidence of the effect of great floods of water coming down occasionally at other times of the year; and the risk of such floods arising suddenly is ever present to the Arabs, who uniformly refuse to camp in the water-way of a dry river-bed, but always pitch their tents on one of the lower alluvial terraces. This winding valley, known as Wady Omongraf, leads into the broad expansion of Wady Sidreh, called Syeh Sidreh, or, by Lottin de Laval, "Le ras des quatre Wadys," just above the junction of Wady Mokúttub.

The New Red Sandstone appears again as soon as the open country is reached from Wady Chamilé, occupying the low ground at the foot of the granite rocks, which form a magnificent line of escarpment, about 1500 or 2000 feet high, running generally east and west towards Wady Ghenneh, below which point the valley again closes, being cut through hard rocks. The lithological character of the sandstone, though generally similar to that observed on the northern side of the granite, has one marked difference, namely, the absence of the thin limestone forming the middle member of the series, so that it becomes difficult to correlate the sections exactly; and this difficulty is increased by the fact that the beds are not in their normal position, but are faulted down against the granite on the north, and in like manner brought against higher beds on the southern side of Wady Sidreh.

Ghenneh.—The valley known as Wady Ghenneh is formed by the junction of three or four tributaries, the most important being that on the western side, called Wady Maghara. The lower part of the gorge below the junction is narrow, between steep cliffs of brownish-yellow sandstone, probably representing the upper part of the series; but above this point the country is open, with low hills and broad gravel-terraces, until the granite is reached. This last rises as a bare cliff, without the slightest vestige of alluvial soil or loose covering of any kind, to about 1500 feet above the plain or downland below. That the line of demarcation between the two kinds of rock is a fault is evidenced by a small outlying patch of the lower red sandstones, resembling a low obelisk on a broad base, crowning the highest point of the hill, and forming the peak known as Dehemi, at the head of the Ghenneh valley.

A large dyke breaks through the sandstones near their northern boundary, and appears to have flowed over the higher beds, leaving a thick mass capping a great portion of the hills to the south. Lithologically this lava is generally similar to that seen near the head of the Chamilé pass.

Mines of Wady Maghara.—Turquoise-mining has been carried on in the sandstones in Wady Sidreh, about 250 feet above the valley-level, and more extensively on the right-hand side of Wady Maghara, where the workings are at about the same height, and extend for about 300 yards along the face of the cliff. They are in two beds, about 15 or 20 feet apart, in different parts of the district, the most considerable being in the upper one. The rock is a soft coarse-grained quartzose sandstone, of a light-yellow colour, mottled with red and brown patches where more ferruginous. The turquoises are found lining the small open joints which cross the rock in a general north and south direction, and also in the solid sandstone a short distance from the joints, the best stones being found in the latter position, where they usually occur (more especially the larger ones) in the centre of small red marly or ochreous nodules. Those in the open joints are generally dull and white, or at the best of a pale-blue tint; and as a general rule it may be said that the redder the rock the finer will be the colour of the turquoises it contains. These conditions of occurrence, although they can only be taken as applying to the rock as now exposed, probably are generally similar to those that governed the explorations of the ancients, as we see everywhere large areas (say from 30 to 40 yards square) excavated with only the smallest of pillars, and these very often much undercut, with occasionally a kind of level or stope along the course of a crack, where a nest of mineral was probably found. The general system of working appears, therefore, to have been pretty much the same as that now adopted by the Arabs, namely, to follow the joints, removing the rock adjoining the side, which is then broken small and sifted through a sieve of about half-inch mesh. The whole of the coarser fragments kept back are then taken to the mouth of the cave, where they are carefully picked over in daylight. The likely-looking nodular pieces are rubbed down on a piece of rough grit, in order to see whether they contain turquoises or not; and if any blue colour is made apparent by this treatment, the stone is considered to be worth keeping.

Since the mines were abandoned by the late Major Macdonald in 1865, no regular operations of any consequence have been carried on, the latest having been undertaken by a Frenchman, about two years since, in the lower caves of Wady Sidreh. It is said that he made a successful venture. The principle adopted in working was to provide the Arabs with tools and powder, paying a small daily wage in addition. The turquoises produced were then purchased at a rate agreed upon beforehand. A somewhat similar system was followed by Major Macdonald; and it is no doubt a fair arrangement for both sides, having regard to the inhospitable nature of the country, which is such as to prevent the introduction of foreign miners; but unfortunately it is not easy to be sure of getting the whole of the produce, as the larger and more valuable stones command a ready sale in Egypt, and are often kept back, only the smaller and inferior ones being handed over to the person providing the means of working.

Old Mining-tools.—The ancient workings in Wady Maghara, although much encumbered by cliff-falls at the outside, are for the most part accessible for a considerable distance from the surface, and in many instances the old faces of work may be seen. These are covered with small and irregular tool-marks, of such a character as to leave no doubt that they have been made with flint flakes, great numbers of which are found strewing the valleys and hill-sides, as well as within the workings themselves. Most of these flakes are of a triangular or trapeziform section, brought up to a point, which is generally well worn and rounded, and the shape of which, when blunted, corresponds perfectly with the grooves on the face of the rock. In one of the smaller caves, carefully examined by my friend Mr. J. K. Lord, the floor was covered to a considerable depth with a coating of impalpable dust, which, when disturbed, rose in suffocating clouds. On sifting this, numerous fragments of stone hammers and pieces of wood, some partially carbonized, but which had evidently been fashioned into tools, were found. The latter form segments of cylindrical blocks, with roughly conical points (that have evidently been shaped with a blunt or imperfectly cutting tool) with a thickened head, notched round underneath as if to receive a withe or cord. The head bears evident marks of having been subjected to repeated blows. Although only a single segment of any degree of perfection was found, there can be little doubt that these were used as mountings for the flint chisels employed by the ancient miners. Without something of the kind, it would be difficult to work with the flakes, owing to their tendency to break across when not struck fairly on the top.

The hammers found in the workings are mostly of a very rude kind; in many cases rough natural fragments of dolorite, taken from the flow capping the adjacent hills, have been used, only a pair of holes on opposite sides, produced by the action of sand pressed upon the surface by the thumb and forefinger, being apparent. Some, however, show a little more work, having a groove, to receive a withe handle, cut round them, like the so-called Aztec hammers found in the aboriginal workings in the Lake Superior copper-mines. Most of them are broken at the ends, and can only be regarded as spoiled and waste tools. The same seems to be the case with the wooden fragments, many of which are partially carbonized, as though they had been used for making fires when no longer serviceable as tools; and the same remark also applies to the flint flakes. The period over which the working of the mines of Wady Maghara extends, according to the evidence of the numerous hieroglyphic tablets covering the face of the cliff, as interpreted by Egyptologists, extends from the 3rd to the 13th Manethonian dynasties, corresponding to an interval of about 1600 years. As far as mining and stone-cutting are concerned, there does not appear to have been much progress during this time, the older tablets being much more perfectly sculptured than those of later date. The use of flints was continued up to the last, as is shown by a blank tablet, dressed smooth to receive an inscription, near the northern end of the workings, which was never finished. This has evidently been done with a flint tool, the proper face being obtained by the use of flakes of small size. The same sort of tools were used at Sarabut el Khadem, where the workings are of later date; but there the hammers appear to be of a somewhat more advanced type.

That the mines of Wady Maghara were worked for turquoises, and not for copper-ores, may be assumed from the absence of all traces of slag-heaps like those of Nasb. In the old town, on the hill dividing Wady Maghara from Ghenneh, a shot of copper was found in the bottom of a broken earthenware pot. This was probably accidental, and owing to the presence of a fragment of some easily reduced copper-ore in the clay. The inhabitants were, however, not entirely without metal, as a small bracelet of copper was found in a tomb, the only one remaining unopened, in Wady Sidreh, associated with lance- and arrow-heads of flint, and a necklace of beads formed of spiral marine shells bored through for stringing.

Alluvium of Ghenneh.—The alluvial deposits of the Ghenneh valleys have certain features of interest in connexion with the ancient mines. The downland at the foot of the granitic escarpment is covered with a gravel made up of pebbles of red, yellow, and white quartz, and brown sand from the waste of the Triassic sandstones; a few pieces of fossil wood were also found. The watercourses are bounded by steep and terraced cliffs, mainly of granitic detritus, of a coarse but comparatively uniform grain ($\frac{1}{4}$ inch); but in the central valley these are bordered at lower levels by a coarser gravel, with good-sized boulders, probably indicating the return of a more rapidly flowing stream in later times.

In the finer alluvium a single but unbroken shell of a large freshwater bivalve was found, which, on comparison, proves to be identical with the large Anodon-like form, *Spatha Chaziana* (Lea), now living in the Nile. Broken fragments of the same shell were also found in the mine, accompanying the stone and wooden tools already mentioned, and apparently having been carried in by the miners for food. These latter are well preserved, the nacre of the interior being fresh and brilliant; but the shell from the gravel is rough and white, having lost all trace of its original polish and colour. Unless, therefore, we suppose that these shells have been brought from the Nile, which is not very likely, as the distance is about 300 miles, we must admit that, in the days of the old miners, the Ghenneh plain and valleys were sufficiently well watered to allow of large fluviatile mollusca living in them. But even supposing the shells to have been imported, the inference is that a great part of the gravels have been deposited, and fresh channels cut through them, in the last 4000 years.

Alluvium of Wady Ferran &c.—The evidence, however, of the existence of lakes or slow-flowing rivers in Arabia Petræa is not confined to the somewhat doubtful case given above. In the upper part of Wady Ferran and the higher valley of Wady el Scheick, which are cut through a comparatively soft grey granitic gneiss, there are considerable accumulations of fine-grained well-stratified alluvium, forming terraced masses which, although much eroded by subsequent action of the weather, often attain a height of from 40 to 60 feet above the bottom of the valley. They have been attributed by a recent traveller * to the action of glaciers, and described as moraines; but a close inspection proves them to be only ordinary lake- or river-alluvium, as in places they are full of calcareous nodules (race or kunkur), and also contain beds of calcareous tufa (incrusting the stems of carices or plants of a similar character), as well as freshwater shells, including *Lymnæa truncatula* and a species of *Pisidium*.

* Dr. Oscar Fraas, 'Aus dem Orient. Geologische Beobachtungen am Nil, auf der Sinai-Halbinsel, und in Syrien,' Stuttgart, 1867. See Anniversary Address of the President (W. W. Smyth), Quart. Journ. Geol. Soc. vol. xxiv. p. 211.

The size of these mollusks, which are far too small to be eaten, as well as the position in which the shells were found, is enough to show that they have not been brought in by human agency; so that we are compelled to admit that, within modern times, or at any rate since the formation of the present drainage-system, the Sinaitic climate has been so far different that freshwater mollusks have lived in places that now form part of a dry stony desert.

Cretaceous Rocks.—The sandstone series of Ghenneh is overlain to the westward, in Wady Sidreh and Nagb el Bédra, by Cretaceous rocks. These are principally soft bright-green sands, alternating with thin clayey limestones,—the lowest beds containing numerous Echinoderms. In the long line of escarpment which extends in a south-westerly direction towards Wady Mokuttub the beds are not in their natural order, as the upper part of the sandstones, the brown beds, are first faulted against granite, and then, by a parallel dislocation, with a downthrow in the opposite direction, are brought, at a point immediately south of Wady Ghenneh, against the flint-conglomerate, which is very strongly developed in the form of alternations of coarse flint-shingle with thin coral-limestones and beds with a large coarsely ribbed *Pecten.* The total thickness of this group must be very considerable, as it rises in the hill called Abooalagha to a height of 2424 feet above the sea-level, or more than 1600 feet above Ghenneh; and even this position is due to its being on the downthrow side of a considerable fault. In the direction of Mokuttub the throw of the fault lessens, so that the brown sandstones are brought against a small exposure of Cretaceous rocks (calcareous sandstones and shales with green sands, which are succeeded by a soft grey limestone, covered by a thick bed of blue shaly clay with a little salt and gypsum, and about 500 feet of a soft chalky limestone with bands and nodules of flint, forming an inaccessible cliff, strongly recalling the aspect of an ordinary English chalk-cliff). The total height of the summit above the bottom of Wady Mokuttub cannot be less than 1000 feet. This escarpment goes by the general name of Gharabi.

From Wady Mokuttub the Triassic sandstones take a general south-easterly direction, and are last seen in Wady Ferran, forming a chain of small outliers on the crystalline schists, about twenty miles below the old town. Lower down the latter valley they are again covered by the green sands and thin sandy limestones of the Cretaceous period, having the same south-westerly dip of from 17° to 20°. These, after an outcrop of about $1\frac{1}{2}$ mile along the valley, are covered by the white limestone, beyond which point towards the sea I have not followed the section.

Age of the White Limestone.—Hitherto no opinion has been expressed as to the age of the white limestone, and it now becomes needful to consider this point. On the ground, I was inclined to take the limestone as representing the chalk-with-flints, from the strong physical resemblance to that formation; but we have seen that a like resemblance holds good in the bituminous chalk-with-flints of the Gharandel and Wady Husseid, which are proved by their fossils to be Nummulitic. Another piece of evidence bearing against this view is furnished by the decided unconformity of the limestone upon the greensand in the Gharabi escarpment—although too much stress must not be laid on this point, owing to the number of faults running parallel with the escarpment, some of which may have something to do with the apparent unconformity. The ordinary rule of geological reasoning would perhaps be best satisfied by putting the whole of the chalky beds with flints into the Nummulitic series, as, in addition to the Nummulitic form near Gharandel, the few small fossils found in Wady Taibe, Wady Husseid, and the Marcha are, for the most part, when recognizable, Tertiary forms. As far as I can gather from books, a somewhat similar difficulty is experienced in Egypt, where the upper line of the chalk is rather arbitrarily drawn at certain soft limestones which are not very different in character, except as regards their fossils, from the lower Nummulitic beds immediately next in succession. This makes it probable that the transition from the Cretaceous to the Tertiary period in these regions was not marked by any great break physically, the beds immediately before and after the change having been accumulated under similar conditions; and probably in the Red Sea at the present day the beds accumulating are of an essentially chalky nature. In more recent times, however, a great break must have occurred between the Nummulitic and the flint-conglomerate formations, as the latter is entirely made up of the waste of the rocks immediately preceding it; and how considerable this waste must have been is evidenced in the ridge of Abooalagha, where a mass of strata, about 600 feet thick, is about half composed of conglomerates, none of which contain a single pebble that can be referred to the New Red Sandstone, all being of flints.

After leaving the New Red Sandstone in Wady Ferran, the whole of the country up to the convent of St. Katherine, in Sinai, with the exception of the fossiliferous alluvium in Wady el Scheick, is made up of crystalline and metamorphic rocks, which will not be further alluded to here, as I hope to make them the subject of a future communication to the Society.

Conclusion.—The order of succession of the rocks mentioned in the foregoing account may be summarized as follows, in ascending order:—

1. Gneiss and granites.
2. Triassic rocks, including { 1. Lower Red Sandstones. 2. Limestone with encrinites. 3. Upper Brown Sandstone. }
3. Cretaceous rocks. Green sands with Echinoderms, sandy limestones, and shales.
4. White limestone with flints. { Lower part possibly Cretaceous. Upper part bituminous, with Nummulites. Eocene. }
5. Flint-conglomerate with corals. Miocene.
6. Great gypseous series of Wady Taragi.
7. Reconstructed gypseous series and conglomerates.
8. Raised beaches and Miliolitic Limestones.
9. Alluvium and Desert Drift.

Volcanic rocks appear at two periods; the older are post-Triassic but probably præ-Cretaceous, and the newer contemporaneous with the flint-conglomerate.

Notes on some Specimens of NUMMULITIC ROCKS *from* ARABIA *and* EGYPT. By Prof. RUPERT JONES, F.G.S.

Mr. H. BAUERMAN having requested me to examine a series of typical specimens of the Nummulitic rocks brought by him from the East, I append the following remarks on eight specimens, including a Strontian crystal, containing some Nummulites and other organisms, from near Cairo.

Specimen No. 1. "S. of Wady Gharandel, 7 April, 1868." (Greyish brown asphaltic Nummulitic limestone, weathering white.) Mainly composed of *Nummulina Ghyzensis* *, large and small, with *N. curvispira* and *N. Ramondi*. *Serpula* present.

No. 2. "Asphalt rock, S. of Wady Gharandel, 7 April." Like No. 1, but browner. Contains *N. Ghyzensis* (large and small), pieces of Conchifera, and small fragments of Echinoderms. *Serpula* also is present.

No. 3. "Asphalt Rock, S. of Wady Gharandel, 7 April." Light-brown rock (weathering white), in which *Nummulina Ghyzensis* is abundantly visible throughout, together with *Serpulæ* and some fragments of Echinoderms.

No. 4. "Asphalt Rock, S. of Wady Gharandel, 7 April." A piece of thin-bedded ($\frac{1}{2}$-inch) light-brown limestone, weathering grey on the planes of bedding, and there showing its granular structure and the organic fragments of which it is mainly composed. On one face is a small *Ostrea*, with *Nummulina Ramondi*. *N. intermedia* and pieces of *Pecten* (?) and of Echinoderms are seen in the mass.

No. 5. "Asphalt Rock, near Gharandel, 7 April." No definite organic remains are visible in this brown rock. It has the darkest colour of all the specimens. By treatment with acid, it is found to contain 90 per cent. of carbonate of lime and 10 per cent. of carbonaceous matter, which remains as a brown powder, easily inflamed, burning with a bituminous odour. This substance is in sufficient quantity to colour the limestone, and to give it when warmed by the hand a bituminous smell; but it is not dissolved out of the rock in any appreciable quantity by boiling in turpentine-spirit or in petroleum.

No. 6. "Lowest rock seen just beyond Pharaoh's Fall, 7 April." A limestone altered by the agency of mineral springs, showing hollow casts and remnants of *Nummulina Ramondi* and *Operculina canalifera* (?).

No. 7. "Nummulitic Limestone-gravel of Wady Gharandel, 16 June." Bluish-grey limestone full of *N. Ramondi*. Subangular, polished by sand-action.

No. 8. A Strontian crystal, from near Cairo, containing *Nummulina Ramondi*, and a Polyzoon comparable with *Eschara Thompsoni*, D'Archiac & J. H. 'Foss. de l'Inde,' pl. 36, f. 2.

* In writing of *Nummulites Ghyzensis* (Foss. de l'Inde, 1853, p. 95), D'Archiac states, "As yet *N. Ghyzensis* is peculiar to Egypt. It abounds especially in the Arabian range, in that of Mokattam to the East of Cairo, and on the lower slopes of the mount Sinai massif, where it is associated with *N. Ramondi*, whilst in the Desert west of Cairo it is accompanied by *N. Lucasana*, var. β."

Discussion.

Mr. Gwyn Jeffreys corroborated the opinion of the author, that there had been at one time permanent marshy lands where he found *Lymnœa truncatula* and a species of *Pisidium*.

Mr. D. Forbes inquired the age of the schists and porphyries of Om Riglaine, and as to the character of the granite.

Sir R. I. Murchison inquired the probable age of the masses of gypseous rocks, and commented on the extremely wide range of the Nummulitic strata.

Dr. Duncan remarked that the Cretaceous fossils, as had been observed by both M. Louis Lartet and himself, belonged to the Upper Greensand formation. He considered that the author had proved that the Red Sandstone was not, as suggested by M. L. Lartet, Neocomian, but either Triassic or Permian. Fossils of the Upper Chalk with flints he found to be absent. He had found that, out of 25 Cretaceous species, 13 had been described by M. Coquand from Kabylia and Egypt, while 8 were European forms.

Mr. Etheridge considered the fossils from the sandstone to belong to the Trias, especially from the presence of *Encrinus moniliformis*.

Prof. T. Rupert Jones regarded the Nummulites as of the common typical form found in Egypt—the *Nummulina Ghyzensis*, with *N. Ramondi* and varieties. If the Nummulitic rocks were overlain by the soft white friable limestone, this latter, like similar beds in Scinde, would be of later date, though similar in lithological character to a bed spoken of as being underneath.

Mr. W. W. Smyth had found in Nubia, above the Catacombs, red sandstones overlain by limestone and Nummulitic beds. If the Red Sandstone, as seems probable from the fossils discovered by Mr. Bauerman, were proved to be Trias, a great point in the geology of Sinai and of the East had been gained.

Mr. Boyd Dawkins inquired as to the evidence of the mines having been worked by the Egyptians.

Mr. Evans was not satisfied that the flint flakes had been used in the manner suggested, as they would be liable to break off in the socket, and the hammers would not be worn away in the manner they exhibited by mere impact on wood.

Mr. Carruthers remarked that the fragment of wood exhibited had not been used as a wedge, as the fibres were not in any way disturbed, as they would have been by the impact of a hammer. He believed that it was broken from a much worn mallet made of coniferous wood.

The President commented on the similarity of the faunas of India and South Africa, and hoped that Mr. Bauerman's future researches might throw light on the ancient connexion of these continents.

Mr. Bauerman stated in reply that he did not regard the white limestone as true chalk. He considered that the slabs showed conclusive evidence of having been chiselled by means of the flints.

2. *On the* Occurrence *of* Celestine *in the* Nummulitic Limestone *of* Egypt. By H. Bauerman, Esq., F.G.S, and C. Le Neve Foster, D.Sc., B.A., F.G.S.

The fact of the occurrence of sulphate of strontia in the Eocene rocks forming the great escarpment of Mokattam to the east of Cairo has already been noticed by geologists, the latest and most complete account being that contained in Dr. Fraas's description of the Tertiary strata of Egypt *. The object of the present communication is to furnish some additional particulars in connexion with the position and mode of occurrence of the mineral.

The Mokattam escarpment forms a long connected line of cliff, for the most part nearly inaccessible in front, but which can be easily ascended from some of the numerous lateral ravines. The highest point even commands the old citadel, and has therefore been fortified. The height is probably about 800 feet above the Nile; that of the citadel being 567 feet, by a single barometrical observation. The beds are almost flat, having but a slight dip towards the desert. In a northerly direction the hill diminishes rapidly in height until it is covered by the red quartzose millstone-rock of Jebel Achmar.

Apart from palæontological considerations, the Nummulitic escarpment, owing to a well-marked physical division, may be divided into two parts, the white and the brown beds, the latter being the higher member of the group. The lower, or white beds, are said by Dr. Figari Bey †, to rest upon tufaceous and slightly argillaceous limestone, representing the upper part of the Cretaceous formation.

The following is the observed section in ascending order, commencing in a quarry at the back of the Tombs of the Caliphs, where the ridge is not quite so high as it is behind the citadel ‡:—

		ft.	in.	ft.	in.
White Beds.	1. Soft white limestone, compact and without joints over the entire quarry-bank. It is worked for flooring-slates	10	4	116	7
	2. Buff and brown limestone, more fossiliferous than No. 1	14	10		
	3. Sandy marl parting	0	5		
	4. Bluish-grey limestone with *Nautili* and large Nummulites	48	0		
	5. Rubbly oyster-bed, thickness variable	4	0		
	6. Soft shelly beds, covered by quarry-rubbish	9	0		
	7. White limestone, seamed with brown streaks	30	0		
Brown Beds.	8. Compact brown sandy limestone, the upper part cindery, containing celestine	4	0	54	8
	9. Marls, with fibrous gypsum (have been worked)	4	5		
	10. Hard, brown, sandy limestone, with casts of fossils	3	9		
	11. Variegated yellowish-brown and white sand	4	0		
	12. Hard, brown limestone, much honeycombed	5	3		
	13. Sand and shale	2	0		
	14. Hard brown stone, like No. 12	3	10		
	15. Brown honeycombed limestone, irregularly bedded, with sand and brown iron-ore interspersed	22	5		
	16. Brown beds like No. 15, but more calcareous	5	0	171	3

* Aus dem Orient, Stuttgart, 1867.

† Studi scientifici sull' Egitto, vol. i. p. 136.

‡ The character of these rocks varies rapidly in a short distance. The height of the section in the escarpment behind Old Cairo is about 400 ft.; and the white and brown beds are separated by nearly 100 ft. of gypseous shales with nodules of pyrites, which have been changed into brown iron-ore and gypsum. The dip is generally N. 70° E. at an angle of from 3° to 5°.

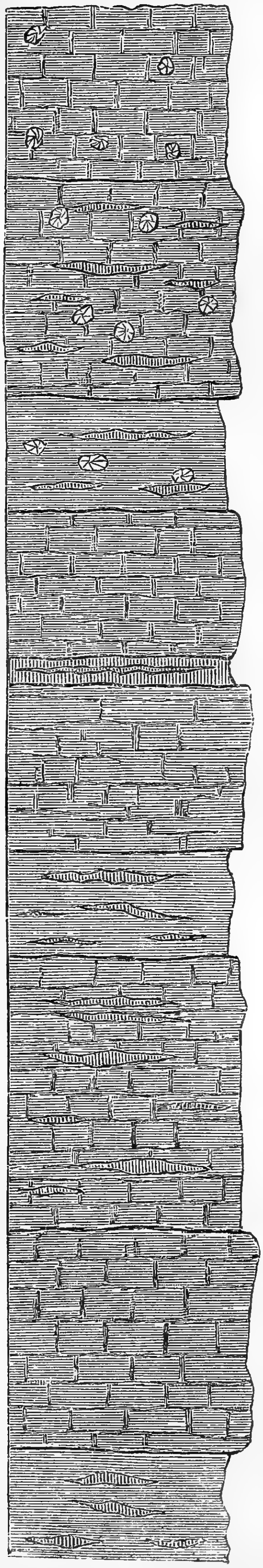
The brown beds at the top of the escarpment are so irregular in their appearance that it is difficult to continue the section; probably there are from 20 to 30 feet more of similar beds at the top of the plateau. The lowest bed (No. 1) appears to be that regarded as forming the top of the chalk by Dr. Figari Bey.

One of the most marked horizons in the whole section is what may be called the big-Nummulite bed, which contains the large species of *Nummulites*, examples of which may be found up to $2\frac{1}{4}$ inches in diameter. It lies about 80 feet below the junction of the white and brown beds, a position corresponding to the lower part of bed No. 4 in the above section.

Along the lateral valleys the gypsum-marls (No. 9) have been subjected to considerable atmospheric degradation, and large pieces of celestine are common in the talus formed by the waste of the hill. They are partially rolled, of a dull bluish-grey colour, and compact, forming either long prismatic forms, from the combination $OP . \infty \breve{P}\infty$, or similar combinations tapering to one end, having formed part of a spheroidal aggregate of crystals, terminating externally by the planes of the diagonal prism ∞P. On examining the cliff-section these spheroids or nodules are found in place in the sandy limestones and marls, together with fibrous gypsum. They show a roughly stellar aggregate of crystals, with a dull earthy centre, the largest examples being about 4 inches in diameter.

The following (p. 42) is a measured section of the principal celestine-bearing beds where they are well-developed; it is taken in a gulley behind the main escarpment. In addition to these there is another bed with nodules of celestine, a few feet below bed No. 10.

About 30 feet below the junction of the white and brown Nummulitic beds there is a very singular development of celestine crystals in the hollows of a white fossiliferous limestone. They are mostly long prisms of the open form $OP . \breve{P}\infty$, often of considerable size (up to 4 or 5 inches in length), and almost always very rough and decomposed about the ends in the plane of the prismatic faces ∞P. Besides the simple crystals, macled groups of two, arranged similarly to the diagonal cuneiform twins of Staurolite, and similar combinations of three or more crystals of greater complexity are found, although not quite so abundantly as the former. In either case, however, the surfaces of the crystals generally seem to be incrusted with fragments of shells, Bryozoa, and small Nummulites, as though they had formed points of adhesion for these organisms. But that this is not the case, is proved on closer inspection, as the shells often pass right through the crystal; and on subjecting some of the more perfect specimens to cleavage, transparent plates were obtained with Nummulites enclosed. It is evident, therefore, that the fossils must have been entangled in the crystals at the time of their formation, and that their subsequent exposure is due to the action of solvents, which have removed the sulphate of strontia, leaving the carbonate of lime, forming the shells and Nummulites, untouched. The hollows in which the crystals are found are generally empty, owing to the original contents having been partly removed by the action of the atmosphere;



	ft.	in.
1. Limestone with a few celestine nodules.		
2. Limestone with much nodular celestine and thin plates of fibrous gypsum ...	1	0
3. Sandy marls with nodules of celestine and fibrous gypsum	0	6
4. Sandy limestone	0	8
5. Gypsum with marl	0	1
6. Sandy limestone	0	10
7. Sandy marls with plates of fibrous gypsum	0	6
8. Sandy argillaceous limestone and gypsum	1	3
9. Sandy limestone	1	0
10. Gypsum and marls	0	6
	6	4

but in a few instances some of the smaller druses were found in what may be considered to be their original condition. They are then filled with a soft impalpable powder consisting of carbonate of lime, often containing a considerable number of small but perfectly formed crystals of celestine; these are not attached to the rock, but are loose in the powdery matrix. The form is in all cases the well-known combination $\breve{P}\infty \,.\, \frac{1}{2}\bar{P}\infty \,.\, OP \,.\, \infty P$, characteristic of the celestine of Girgenti in Sicily. The angles correspond perfectly with those given in Dana's Mineralogy. The twin planes are $\infty \breve{P}\infty$ for parallel, and ∞P for intersecting macles. The latter are often of considerable size, forming St. Andrew's crosses from 2 to 3 inches in length. The smaller and more perfect crystals are generally without included fossils. On comparing a great number of crystals of both kinds, it becomes easy to trace the progress of the decomposition, which invariably begins by a roughening of the faces of the prism, owing to the formation of a number of fine grooves or striations parallel to the basal cleavage. The action of the solvent goes on in the same way, enlarging the grooves until a great part of the interior of the crystal is eaten away, leaving a funnel-shaped cavity where the prism-faces formerly existed; and this may continue until the whole of the original form has been removed. In proof of this may be mentioned the occurrence of a limestone-pseudomorph after celestine: only a single specimen was found; and the crystal replaced was so rough that it was somewhat difficult to make out at first; but when broken, the comparative sharpness of the basal plane was at once apparent. More generally, however, the transformation stops short of a complete change, the crystals being rough and hollowed at the ends and sides, but keeping their freshness, and even in some cases their colour, on the basal planes. The partially destroyed crystals then form a basis for a secondary growth of the same mineral; but these new crystals are remarkable for their brilliancy and perfection; the form is the regular Girgenti combination, but they are generally somewhat squarer and thicker, and are free from included fossils. The largest of these secondary crystals measured about 3 inches in length and $1\frac{1}{2}$ inch between the basal planes, and is perhaps the largest known example of this form, the American crystals from Strontian Island on Lake Erie, though larger, being of a different character.

The fact of the occurrence of fossils in the older celestine crystals is sufficient to show that they are of synchronous origin, or that the crystals have been formed by gradual deposition from a tolerably concentrated solution, such as might be imagined to exist in a sea whose bed was diminishing from the evaporation of the water. The hollows in the limestone may be compared to small basins where the crystallization took place, any fragments of shells, small Nummulites, and Bryozoa (either living or dead, but probably the latter) that happened to be present in the calcareous mud having been entangled up and enclosed. Forchhammer* obtained sulphate of strontia direct by evaporating sea-water, and Wackenroder, in 1836†, pub-

* Bischof, vol. i. p. 449 (2nd edition).
† Ann. Chem. und Pharm. vol. xli. p. 316.

lished the following statement relating to the solubility of the sulphates of the alkaline earths in chloride of sodium:—"Sulphate of baryta is insoluble; sulphate of strontia slowly but completely, and sulphate of lime readily soluble in an aqueous solution. The former of the two soluble salts is reprecipitated when dilute sulphuric acid is added, whereas sulphate of lime remains in solution." We have thus a simple explanation provided for the erosion of the crystals, which may have taken place either after subsidence and the readmission of the sea-water within the former dried-up area, or perhaps more simply by the infiltration of atmospheric water through the upper part of the Tertiary rock, the whole of the sedimentary formations of Egypt and Arabia being more or less charged with rock salt. Accumulation of salt water, when set up by either method, would act upon the celestine crystals, removing the soluble sulphate of strontia, leaving the Nummulites and other calcareous fossils behind. When, however, any stagnation and evaporation of the solution took place, the dissolved sulphate would be redeposited and, the mechanically included impurities being separated, the new crystals would be more compact and less liable to change than those first formed.

Besides its occurrence in detached crystals, celestine is also found in the Mokattam escarpment filling up the interior of fossil shells, especially the chambers of Nautili. Fraas gives the following analysis by Bergrath Jerzoch of a specimen of celestine taken from the inside of the shell of a *Nautilus zic-zac*:—

Sulphuric acid	43·87
Strontia	55·56
Lime	0·68
Loss on ignition	0·64
	100·75

The conclusion drawn from this is, that it is a celestine containing a small quantity of sulphate of lime. It is more probable, however, that the lime may be there as carbonate from the presence of included shells.

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3. *Note on the* Echinodermata, Bivalve Mollusca, *and some other* Fossil species *from the* Cretaceous Rocks *of* Sinai. By P. Martin Duncan, M.B. Lond., F.R.S., Sec. G.S.

The fossils collected by Mr. Bauerman from the Cretaceous strata above the red sandstone in Wady Nagh el Bader, Wady Ferran, Sidreh, and Tih during his explorations in 1868 are numerous, and some are in good condition. They present the facies so clearly stamped on the collection described by me on December 6, 1866*. The fossils which formed the groundwork for a comparison between the Sinaitic and South-eastern Arabian Echinodermata, and which were collected by the Rev. F. W. Holland, when examined critically, decided the Upper-Greensand age of the limestones in

* Quart. Journ. Geol. Soc. vol. xxiii. p. 38.

Wady Bader. One Echinoderm, *Heterodiadema Libycum*, Agass. et Desor, sp., was noticed to afford some evidence of the zone of Hippurites in Sinai; and now Dr. Le Neve Foster in his section (cf. Tih) points out the existence there of Hippurites; and Mr. Bauerman's collection contains some from Wady Nagh el Bader. The propriety of the assertion that a Turonian as well as a Cenomanian chalk existed in Sinai is therefore to be admitted. Mr. Bauerman and his colleagues have added by direct observation a higher stage to that previously known to exist amongst the Cretaceous series in the west of the Sinaitic peninsula. There are slight evidences of the existence of a chalk over the Hippurite-limestone; but this must be stratigraphically the base of the white chalk of North-western Europe.

No fossils are in the collection now under consideration, nor were there any in Mr. Holland's, pointing to a Neocomian, Gault, or Upper Chalk horizon (chalk with flints).

A study of M. Coquand's 'Géologie et Paléontologie de la Région sud de la province de Constantine' (1862), and the examination of a collection of Algerian fossils in the possession of John Wickham Flower, Esq., F.G.S., place the affinities and distribution of the Sinaitic Cretaceous fossils in a very definite relation with those of the following étages:—

1. Rhotomagien, 2. Mornassien, 3. Provencien, 4. Santonien?

The Rhotomagien is the African zone of:—

Ammonites Mantelli, *Sow.*	Scaphites æqualis. *Sow.*
—— rhotomagensis, *Brongn.*	Turrilites costatus, *Lam.*
—— varians, *Sow.*	Pecten asper, *Lam.*

It contains a considerable number of Echinodermata and Ostreæ; and the commonest of these are found in Mr. Bauerman's collection.

Coquand's Carentonien (the zone of *Aspidiscus cristatus*, Lam. sp.), has not been traced in the Sinaitic chalk, nor has his Angoumien series; but the Mornassien, the zone of the Echinodermata *par excellence*, immediately beneath the zone of *Hippurites cornu vaccinum*, and the Caprotinas (the Provencien) are well represented there. The Provencien is distinguished in the present collection by the Caprotinas.

The following is a list of the species found by Mr. Bauerman, with their localities in Sinai, Algeria, Europe, and in other parts:—

1. Discoidea subuculus, *Klein.* Tih: Rhotomagien, Upper Greensand.
2. —— Forgemolli, *H. Coquand.* Tih: Rhotomagien.
3. Epiaster distinctus, *Agass.* Wady Nagh el Bader: Zone of *Pecten asper* and N.E. Arabia.
4. —— tumidus, *Desor.* W. N. B.: Cénomanien, France*.
5. Periaster oblongus, *D'Orb.* W. N. B., Tih: Cenomanien, France.
6. Hemiaster Cenomanensis, *Cotteau.* Tih, W. F., W. N. B.: Cenomanien, France; Bagh.
7. Phymosoma Delamarrei, *Desor.* W. N. B.: Mornassien.
8. Pseudodiadema variolare, *Brongn.*, sp. W. N. B., Tih: Upper Greensand, Red Rock.

* W. N. B. = Wady Nagh el Bader. W. F. = Wady Ferran.

9. Pedinopsis —— ?
10. Plicatula Fourneli, *H. Coquand.* W. N. B.: Rhotomagien.
11. Pecten asper, *Lamk.* W. N. B.: Rhotomagien, Upper Greensand; Europe.
12. Neithia alpina, *D'Orb.* W. N. B.: Upper Greensand; S.E. Arabia.
13. —— tricostata, *Bayle*, sp. W. N. B.: Rhotomagien, Upper Greensand; Provence.
14. Exogyra plicata, *Goldfuss.* Tih, W. N. B.: Upper Greensand; S.E. Arabia.
15. Ostrea Auressensis, *H. Coquand.* Tih, W. F., W. N. B.: Rhotomagien.
16. —— ——, var. major, *nobis.* W. N. B.
17. —— Mermeti, *H. Coquand.* Tih: Provencien.
18. Exogyra Overwegi, *Buch.* Tih, W. N. B.: Rhotomagien.
19. Ostrea Delattrei, *H. Coquand.* N. Z.: Rhotomagien.
20. —— curvirostris, *Nielson.* W. N. B.: Santonien.
21. Caprotina Toucasiana, *D'Orb.* Provencien, Upper Greensand; Europe.
22. —— subæqualis, *D'Orb.* Provencien, Upper Greensand; Europe.
23. —— Archaisianus, *D'Orb.* Upper Greensand; Europe.
24. Radiolites —— ? W. N. B.

It will be observed that 13 out of the 24 species are common to the North-African and Sinaitic Cretaceous rocks, and that 8 other species are well-known European forms.

The commonest fossils in the collection are *Ostrea Auressensis, Exogyra plicata, Plicatula Fourneli, Periaster oblongus, Hemiaster Cenomanensis,* and *Pseudodiadema variolare.* The first of these is evidently one of a great series of varieties having a clear reference to *Ostrea columba.*

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4. *On the* EXISTENCE *during the* QUATERNARY PERIOD *of a* GLACIER *of the* SECOND ORDER *occupying the* "CIRQUE" *of the* VALLEY *of* PALHÈRES, *in the Western part of the* GRANITIC "MASSIF" *of the Lozère.* BY M. CHARLES MARTINS, For. Corr. G.S., Director of the Botanic Garden, Montpellier.

[Abstract*.]

M. MARTINS refers to the general absence of indications of ancient glacial action in the mountains of central and southern France, and to those circumstances of structure and mineral constitution by which, in some cases, this absence may be accounted for. He describes those features in the conformation of the valley of Palhères, in the Lozère, the representation of which, in the Government Map of France, led him to the conclusion that in this place traces of glacial action might probably be met with. In the gorge in which the village of Palhères is situated, enormous granitic blocks occur; but these are always either in the torrent, or so near it, that the evidence furnished by them is very doubtful. Above Palhères is a vast "*cirque*," in which the hamlet of Costeilade is situated; and here the ground is sprinkled over with erratic blocks, ascending to a considerable height on the slopes of the mountains. The *right lateral moraine* terminates in a rectilineal crest formed of disintegrated material, but resting on a boss of mica-schist separated from the right

* This paper is published in full in the 'Comptes Rendus de l'Acad. des Sciences,' 9th November 1868, tom. lxvii. pp. 933–937.

counterfort of the valley by a deep ravine. This crest is terminated by a rock of mica-schist, also separated from the right counterfort; and upon this three isolated granitic blocks are perched. A stream of blocks thrown in line on the corresponding counterfort of the valley below the schistose rock shows the extreme termination of the glacier beyond the gorge. As the summits bounding the right side of the valley all consist of mica-schist, these granitic blocks cannot be regarded as having fallen from above. The *left lateral moraine* includes the blocks scattered about the hamlet of Costeilade: some of these project from the ground in cultivated fields; and one, the last, is perched on a promontory of mica-schist, overhangs its pedestal, and resembles in form the head of a geological hammer. This is about 150 metres above the torrent. The peaks and crest about the left moraine are granitic, and considerable masses of rock have fallen from them; but there is an interspace of about 250 metres between the foot of these and the highest blocks of the moraine. The *terminal* moraine is better marked than the lateral ones, and corresponds with the gorge which closes the "*cirque*" of Costeilade. The moraine forms a bar between the left counterfort of the valley and a low, rounded, isolated hill of schist which occupies the line of the water-way and drives the torrent towards the right. This isolated hill is remarkable. Rounded on the upper side, it is produced below into a crest of less elevation than itself, which bears only two small erratic blocks; the hill itself on the contrary bears 32 large granitic blocks, all placed on the upper side, against which the vanished glacier impinged. No polished or striated rocks or scratched pebbles are to be met with; but this is explained by the soft schistose nature of the rock forming the valley, which could neither have scratched the granite fragments, nor have retained any traces of polish or striation on its own surface.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On Flint Flakes *from* Carrickfergus *and* Larne.

By G. V. Du Noyer, Esq., of the Geological Survey of Ireland.

(Communicated by Sir R. I. Murchison, Bart., K.C.B., F.G.S.)

[Read June 17, 1868*.]

[Abridged.]

On the 3rd of March last I had the honour to address a letter to the Director-General of the Geological Surveys of Great Britain, Sir Roderick Murchison, Bart., K.C.B., on the subject of worked flint flakes from the "drift" of the Belfast district, of which the following is an extract:—

These worked flint flakes, of which I send a typical collection to the Museum in Jermyn Street, were picked up by me, during the progress of my geological work last summer, from the gravelly drift and subsoil clay of the districts around Carrickfergus, Larne, and Belfast, in the co. Antrim, and Holywood and Bangor, in the co. Down.

I enclose a list and descriptive catalogue of these flint flakes, which I believe are capable of being subdivided into eleven groups, placing the rudest form of flake in the first.

When these singular implements were discovered, some four or five years ago, in the co. Antrim, along the chalk escarpment, their mechanical origin was questioned; indeed, I thought at first that their primary origin might possibly be due to the natural crushing of the flint nodules, which occur as a conglomerate enclosed in a red or hæmatitic paste, resting on the subaerially eroded surface of the chalk, and therefore directly interposed between it and the basalt,—granting at the same time that the chippings round the edges of the flakes were artificial.

Subsequent examination into the subject, however, clearly showed me that every flake, no matter how rude its form, provided it exhibited that conchoidal fracture called *the bulb of concussion* at any of its edges, is certainly artificial; indeed I have succeeded in making flakes of the primary form myself, showing this peculiar conchoidal fracture.

* For the other communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. xxiv. p. 484.

Specimens illustrative of the manufacture of gun-flints explain most fully the force of the arguments brought forward to prove the mechanical origin of these "drift" flint flakes.

These worked flint flakes occur in two very distinct formations—the most ancient that of the marine drift-sand and gravel which skirts the shores of Belfast and Larne Loughs, in the co. Antrim, and the coast from Holywood to Donaghader, in the co. Down—its maximum elevation being about 20 feet above the level of high water. All the flakes from this deposit are of the ruder forms, and their surfaces are more or less oxidized or rendered white; and though they are imbedded in what was well-washed or rolled sea-drift, the chippings round their sides and angles are remarkably sharp—thus proving that they did not suffer much attrition after their submergence, and before the elevation of the marine-drift to its present subaerial position.

The more recent flakes are found in the subsoil clay, at all elevations up to 600 feet or so, on the northern slopes of the Cave Hill at Belfast, the commons of Carrickfergus, and the lofty ground around Larne Lough, including that of Island Magee.

These flint flakes sometimes occur in groups, and so abundantly that hundreds of them can be collected over a surface of 50 square yards, and they are all more or less characterized by a comparatively fresh look; but they all possess that porcellanous glaze which time alone can give to the surface of a fractured flint.

At one locality on the east coast of Island Magee, at the south end of "the Jobbins," I found a hoard of these subsoil flakes, and on the west shore of Larne Lough, at Ballybig, a similar collection of the older variety of these implements in the marine-drift. Here they were accompanied by large irregularly shaped lumps of flint, on one of the edges of which was preserved the original rounded surface of the nodule, evidently thus left to fit them to the hand, and thus allow of their being used as hammers to fabricate the required flake of flint.

In some rare instances the subsoil flakes, when originally of the arrow-headed type, present near the bulb of concussion (which then becomes the base of the implement) the flint-chipping necessary to form the wing of a perfect arrow- or javelin-head. Flakes of this variety are most usually found in the interior of the co. Antrim, as at Toome Bridge and near Moira.

The Rev. Dr. M'Ilwaine, of Belfast, has kindly allowed me to make some sketches from flint flakes of this character in his collection; and I now beg to present them to the portfolio of the Geological Society, to aid in making as complete as possible the small collection of flint flakes which accompany these remarks *. In some rare instances deep side-notches are observed on the more ancient oxidized flakes from the marine drift; but their position is variable.

So far as our present information leads us, I believe we can arrive at the following conclusions with reference to the origin and mode of occurrence of these worked flint flakes:—

During the formation of our present raised sea-beaches, the in-

* Deposited in the Society's Collection.

habitants of that period resorted to the outcrop of the chalk for flint nodules from which to fabricate such implements as they required of that material. During the process of manufacture many of these implements were rejected as incomplete, or were subsequently lost over the limited area skirting the coast-line of that era, which may have been dry land at low water.

This appears to have been the first era of this manufacture. The second epoch finds the race of men inhabiting the area within some miles of the chalk outcrop possessed of somewhat increased mental and manual ability. They no longer manufactured the flint nodules procurable along the coast-line, where, doubtless, they were most abundant, but they resorted to the absolute chalk outcrop, and carried away with them into the interior the primary flint nodules, and then chipped them into flakes more nearly resembling the arrow-head of subsequent times than those fabricated by their progenitors.

I believe it quite possible that the leaf-shaped flint flakes of this second epoch, such as those found in the bed of the river Bunn, at Toome Bridge, were known to and used by the earliest of the historic races in Ireland, and by them worked into those delicately chipped and symmetrically formed winged arrow-heads, spear-, and javelin-heads which are found so often, associated with rude pottery, beads of amber, glass, and shells, in our sepulchral tumuli and megalithic chambers.

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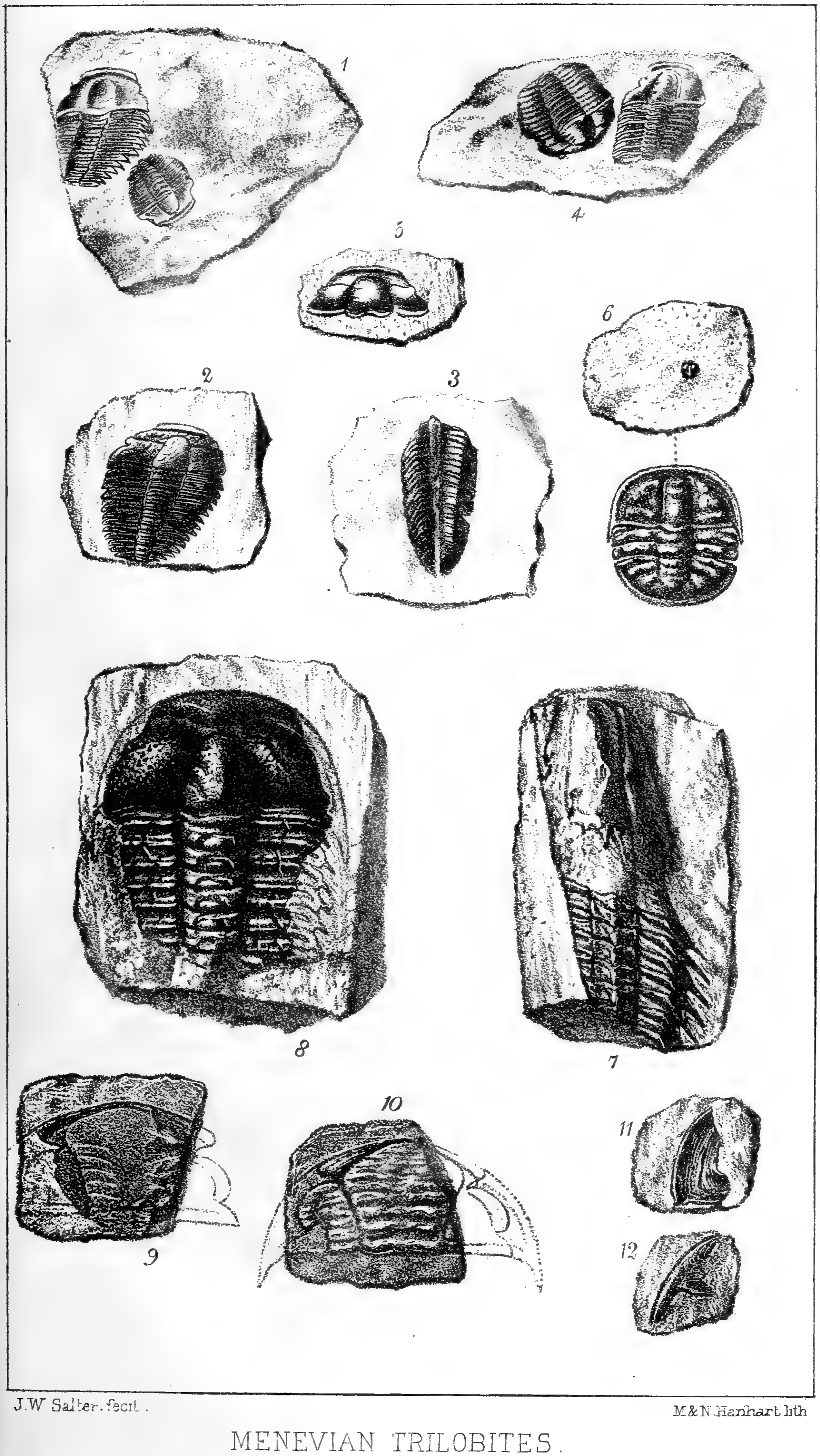
2. *On the* "Waterstone Beds" *of the* Keuper, *containing* Pseudomorphous Crystals *of* Chloride *of* Sodium, *in the* Counties *of* Somerset *and* Devon. By G. Wareing Ormerod, M.A., F.G.S.

(Read June 17, 1868*.)

During a recent visit to Devon, the Rev. W. S. Symonds stated that he thought he had recognized "the Waterstone beds" of the Keuper at Exmouth, this being, it is believed, the first time that they have been noticed in this county. As the point, however, was not clear, I devoted a few days to a cursory examination of the Red Sandstone from Culverhole point, where it crops out from under the Lias, to Exmouth. As some months will probably elapse before I can make a close examination of them, I send the following particulars as marking the position of the rocks of this district in the "Trias." Between Culverhole point and Seaton I could not find Waterstone. From Branscombe Mouth to Weston Mouth I was not able to examine the coast. Between Weston Mouth and Salcombe Mouth many beds of gypsum appear in the cliff; and between Salcombe Mouth and the river Sid several beds of very fully ripple-marked "Waterstone" occur, as also *pseudomorphous crystals of Chloride of Sodium*. This, I believe, is the first instance of the occurrence of such crystals in Devonshire. The coast between Sidmouth and Budleigh-Salterton has not been examined by me. Between Budleigh-Salterton

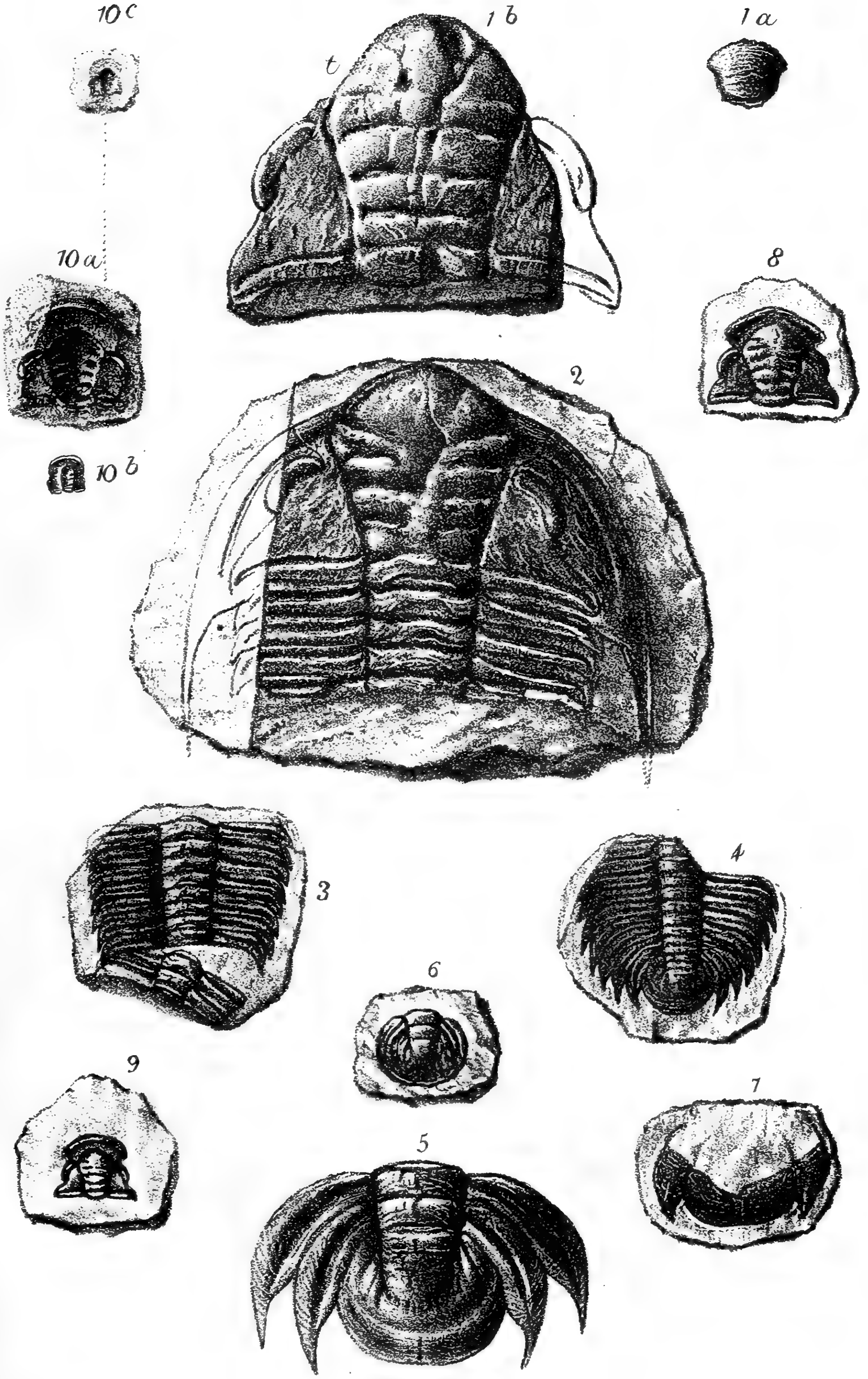
* For the other Communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. xxiv. p. 484.



J.W. Salter. fecit.

M & N. Hanhart lith

MENEVIAN TRILOBITES.



J. W. Salter fecit. M & N. Hanhart imp.

PARADOXIDES HICKSII, *Salter*.

and Littleham Bay "Waterstone beds" and pseudomorphous crystals of chloride of sodium occur. I agree with Mr. Symonds that the beds found near Exmouth are Waterstone, but I have not been able to find there any trace of the pseudomorphous crystals.

In communications made by Mr. Strickland (Quart. Journ. Geol. Soc. vol. ix. p. 5) and myself (Quart. Journ. Geol. Soc. vol. iv. p. 273, & vol. ix. p. 185) it has been shown that these pseudomorphs are found in Nottinghamshire, Cheshire, Worcestershire, and Gloucestershire. I have found them in Somersetshire (at Blackbrook, near Taunton), and now on the south coast of Devon; they therefore occur over the greater part of the area of the Trias in England.

On a small fragment of Waterstone that I picked up on the beach at Exmouth, the marks very closely resemble the reptilian traces found in the Keuper of Runcorn, in Cheshire. As the fragment is small, and reptilian traces have not been found in the Trias in Devonshire, I cannot speak with certainty, but mention the matter in order that the attention of other observers may be drawn to it. A series of small "throws down" to the west appear to intersect the Trias between Culverhole point and Exmouth.

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3. *On some* Fossils *from the* "Menevian Group." By J. W. Salter, Esq., F.G.S., A.L.S., and Henry Hicks, Esq.

(Read June 17, 1868*.)

[Plates II. & III.]

Descriptions of some of the principal fossils of the Menevian formation, including the large *Paradoxides* (*P. Davidis*), appeared in the Quarterly Journal of the Society for August 1864, and others in the number for November 1865; but as many new forms have been obtained since then, a large number yet remain to be described. The continued research, carried on by one of the authors, in the typical locality, St. David's, has been the means of discovering the whole of these new forms, many of which, however, have been subsequently found in various other places. Around the Merionethshire anticlinal ridge of Lower Cambrian rocks large collections have been made:—on the north side, near Maentwrog, and at Tafarn Helig, near Trawsfynydd, by Messrs. D. Homfray and R. A. Eskrigge; and on the south side near Dolgelly by Messrs. T. Belt, E. Williamson, J. Plant, and J. C. Barlow,—all of whom have also done something towards defining the boundaries of the group in North Wales. Much also has been done by us, in like manner, in South Wales, and many new localities have been found to be occupied by this interesting group.

The range of some of these fossils has been more clearly ascertained, and greatly extended. They are not in any way limited to the black Lower Lingula-shales, but occur also in the hard grey rocks which form the upper bands of the Harlech grits.

One of the authors has recently found both Trilobites and Shells

* For the other Communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. xxiv. p. 484.

in a series of red and purple rocks several hundred feet lower; and these will be described by-and-by*. The present communication illustrates only some characteristic Trilobites from the grey beds at the base of the "Menevian Group," and two forms from the black slate series directly above these beds.

Of these we only describe at present *Paradoxides* and *Conocoryphe*, and complete these genera so far as they are yet known in the "Menevian Group" proper. The several species in the genera *Erinnys* or *Harpes, Arionellus*, and *Agnostus*, are still to be described.

1. Conocoryphe bufo, Hicks, Pl. II. fig. 8. Brit. Assoc. Report, 1865, p. 285.

Of this well-defined species, only a few separate heads, and one with six body-rings attached, have been found. It is much the largest species of the genus yet found in the "Menevian Group," being probably no less than 3 inches in length and 1½ in breadth across the head. The head is semicircular, tubercular all over, strongly marginate, with the angles produced into short spines. The glabella occupies nearly two-thirds the length of the head, is very narrow forwards, parabolic and convex, and is indented by three distinct lateral furrows on each side, which run obliquely backwards and reach about one-third of the distance across; length about equal to width at the base, centre ridged slightly, neck-furrow deep, well defined, and arched somewhat upwards in the centre. Occipital ring almost as convex as the hinder part of the glabella. Cheeks wider than glabella, almost equally convex with it, and separated from it by very deep dorsal furrows; their posterior margin is narrow, bent forward near the outer angles, and bears a strong tubercle on either side. Eyes small and scarcely visible, placed very far from the glabella. The facial sutures curve outwards above the eyes, and beneath them are nearly marginal, just cutting off the spinous angles. The outer border, which is narrow round the cheeks, becomes greatly exaggerated in front, and widens to a triangular tumid boss, the apex of which reaches backwards almost to meet the anterior part of the glabella; in consequence of this the marginal and dorsal furrows approximate each other, and become almost merged into one another at this spot. This boss is at least a fourth of an inch wide opposite the apex of the glabella, rises suddenly upwards from the marginal furrow, and then slopes forwards gradually. The whole surface is granular, with some larger tubercles. The thorax, of which six rings only have been found attached, has a highly convex axis, about half as wide as the pleuræ with the attached spines; pleuræ depressed, grooved widely in the cast†, and turned sharply backwards at the

* It is perhaps advisable to mention what these are, leaving their description till another time:—A new genus, *Plutonia*, a *Conocoryphe*, a *Paradoxides*, a *Microdiscus*, *Agnostus*, *Theca*, *Lingulella*, and a new bivalved Crustacean. It really does look as if the changes rung on these early forms were not so much varied as we descend lower in the geological scale. Hence we may hope to reach some point beyond which the variations are zero.—J. W. S., Dec. 1868.

† The shell is probably very thick, and the groove on the upper crust would not be nearly so strong as in the cast.

fulcrum, which is placed rather far from the axis; the spines comprise rather more than a third of the whole length of the pleuræ, and are rather dilated at the base. Our figure does not show these spines; but better specimens have lately been discovered. Tail unknown. This species is easily distinguished from any of the others found in the "Menevian Group" by its large size, wide anterior margin, the small, highly convex, and deeply furrowed glabella, and wide cheeks. Its nearest ally is a new species (*C. perdita*, Pl. II. fig. 3), found by me at the end of last summer, about 200 feet lower down in the Cambrian series (purple and grey beds); but as the last-named species is smaller, and has a far less strongly developed anterior margin, as well as a wider glabella, it is not likely to be mistaken for it, especially when we recollect that the one occurs in the purple Cambrian beds and the other in the "Menevian Group," and that as a rule the range of the species in these lower series extends through but a slight thickness of the strata.—H. H.

Locality—Grey beds at the base of the "Menevian Group." Porth-y-rhaw, St. David's.

2. Conocoryphe applanata, Pl. II. figs. 1, 2, 4, and 5 (juv.). Salter, Brit. Assoc. Report, 1865, p. 285.

Length from ½ to 1 inch, breadth about ½ inch. Form broad-ovate, depressed. Head semicircular, rather wider than the body, surface very slightly tubercular, marginate all round, and angles produced into short strong spines. Glabella parabolic, more or less convex, and indented by three lateral furrows, which, however, are rather indistinct in the most convex specimens; the cheeks are broad and compressed, and bear small but prominent eyes rather remote from the glabella, being distant from it by a space about equal to its width, and connected with it by strongly marked ocular ridges; the facial sutures run forwards and rather outwards above the eyes, and backwards and outwards below, cutting across the hinder margin near the outer angles. Thorax of 14 rings, axis slightly convex, and tapering towards the tail; pleuræ long and narrow, twice as long as the rings of the axis, deeply sulcate, and bent slightly backwards at the fulcrum, which is placed about midway. Tail semicircular, with a tapering, pretty strongly marked axis of three segments; limb marked by three ribs, marginate. This species is distinguishable from *C. variolaris* by many of the characters above given, but especially by the want of the very strong tuberculation and the strongly raised margin of the latter species—and also by the presence of a well-defined ocular ridge, which, if present, is scarcely at all visible in *C. variolaris*. *C. applanata* has no tubercle on either the axial rings or pleuræ, and is altogether a much smaller species than *C. variolaris*.—H. H.

We have been fortunate in finding the very young of this species; it is a capital example of the metamorphosis observed by Barrande in so many of his Primordial forms. The little disk, not more than half a line long (fig. 6*b*), shows, when magnified (fig. 6*a*), no trace of eyes or facial suture. Only two, instead of fourteen, body-rings are visible; and these, as well as the head, are crowded with those characteristic tubercles which are so common in embryo forms of this group, and which indeed are retained long after in certain species and genera. The tail is of the ordinary type, a good deal developed for the size of the animal, and marked with two or three distinct segments, tubercular like the rest.

In these young forms it is impossible not to see the representatives of genera such as *Agnostus,* which has two, and *Microdiscus,* which has four rings in the adult state. The cylindrical unfurrowed glabella and the want of eyes, the few body-rings and the great relative development of the tail, are as conspicuous in the embryo of *Conocoryphe* as in the adult state of the humble forms above quoted. What is the precise nature of the tubercles which are so conspicuous in the embryo of *Sao,* for instance, as given by Barrande, it is difficult to say. I have called attention to them elsewhere.—Mon. Pal. Soc. Trilobites. Monograph, pt. 1 (under *Phacops*), pl. 3, p. 52.—J. W. S.

Locality—" Menevian Group," Porth-y-rhaw, St. David's; also near Maentwrog and Dolgelly, North Wales.

3. Conocoryphe (?) humerosa, Pl. II. fig. 7. Salter, Brit. Assoc. Report, 1865, p. 285.

Of this curious species, a part of the head and six thoracic rings only have been found. These, however, show characters sufficiently marked to indicate that it is specifically (if not generically) distinct from either of the others.

The glabella is large and elongated, reaching apparently to the frontal margin, not furrowed, but sharply ridged centrally, separated from the cheeks by very deep dorsal furrows. Cheeks narrow, convex, and acutely triangular, surface smooth, with no trace of ocular ridges, or facial sutures, or of being strongly marginate; a very strong spine occurs on the neck segment.

The thoracic axis is highly convex, and spinous along the centre; the pleuræ are wide, very deeply furrowed, and terminate in long, tapering spines, which curve sharply backwards; the fulcrum of the pleuræ occurs about midway from the base of the spines to the axis. The pleuræ, without the spines, are only a little longer than the width of the axis, and bend sharply at the fulcrum.

Locality.—" Menevian Group " (middle beds) Porth-y-rhaw, St. David's.

4. Paradoxides Aurora, Salter, Pl. II. figs. 9–12. Brit. Assoc. Report, 1865, p. 285.

A few rather imperfect heads, some loose free cheeks, and unattached pleuræ only have as yet been found; but these are sufficient to indicate a new and very distinct species. Its position, also, in the grey rocks, at the very base of the " Menevian group" renders it a most important species, and necessitates its description even in this imperfect state.

Head semicircular, very slightly angular in front, where it has a distinct but narrow margin. The margin is much wider on the sides, also towards the base of the free cheeks, and is there produced into rather short thick spines.

Glabella large and broad, subpentagonal, wider than the cheeks, nearly attaining the margin in front, not reaching beyond it, as in *P. Hicksii*, next described. It is furnished with five distinct pairs of lateral furrows, besides the neck-furrow; the two lower pairs reach directly across, the next two pairs are almost equally strong with the lower ones, but reach only about a third of the distance across; the anterior pair are short, and curve backwards at their inner extremities, and are situated somewhat in advance of the outer angles of the glabella. Eyes large, approximating the glabella at their upper part; upper edge on a line with the outer angles of the glabella, and with the fourth pair of furrows.

The glabella is unusually large in this species; and though it is angular at the apex, the angle is much more obtuse than in *P. Hicksii*, and is always bounded in front by the narrow margin. The neck also is much wider than that of *P. Hicksii*.—J. W. S.

Locality, grey beds at the base of the "Menevian Group," Porth-y-rhaw and vicinity, St. David's.

5. PARADOXIDES HICKSII, Salter, Pl. III. figs. 1–10. Brit. Assoc. Rep. 1865, p. 285.

Apparently a very flat species; its length is from 3 to 4 inches; the breadth half the width; the general form broad-ovate, but with nearly straight sides; the short spines not interfering with the general shape.

Head subtriangular, produced in front, and terminating posteriorly in very short spines, which do not reach backwards half the length of the thorax (they are unusually short in the specimen figured in Plate III. fig. 2). Glabella very flat, and but little raised above the cheeks; it is unusually long, reaching even to some distance in advance of the front margin, pear-shaped, attaining its greatest width about the anterior third, where it is wider than the cheeks. Thence it tapers forwards to the obtusely pointed front, and backwards, with straight sides, to the narrow neck segment, which is only one-fourth the width of the head.

Four distinct short furrows indent each side of the glabella, equally strong with the neck-furrow; and the lobes thus marked out are of equal size. Some specimens show traces of a fifth pair anterior to these, which bend back at their extremities towards the next pair. These, however, are generally very indistinct. None of the glabella-furrows extend quite across *, but leave a somewhat elevated space down the middle of the glabella; nor do they quite reach the axial furrows, which are well marked.

The eyes are about halfway up the head, and occupy about half the length of the cheeks; they are gently curved downwards and

* Except the basal ones in the young state (fig. 9).

outwards, following nearly the outline of the cheeks. Their upper end is very close to the glabella at its widest part.

The cheeks are triangular, the margin smooth; the surface within it is scrobiculate, but not deeply so. Their margin, which is wide at the base of the spines and sides, is almost entirely lost in front by the overlapping of the large glabella. This is only the case in fully grown specimens (fig. 2.); in the young (figs. 8, 9, & 10) the margin is equal all round, and a considerable space, also, separates the glabella from the anterior margin. This space gradually diminishes as the individual grows; and the glabella enlarges until, as in the fully grown specimen (fig. 2), the margin becomes completely obliterated.

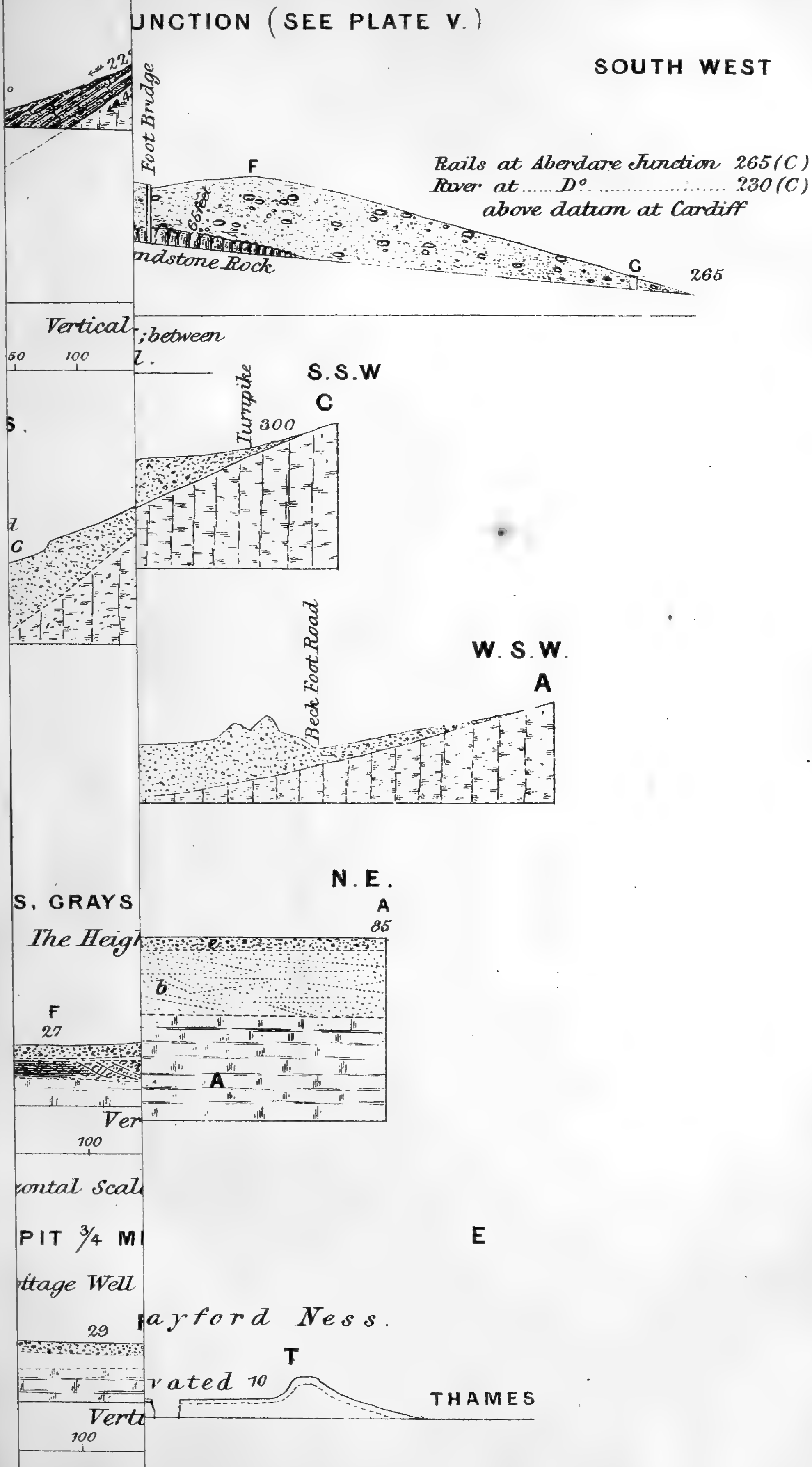
The labrum (fig. 1*a*) is curved, expanded at the base, and truncate at the end, with the angles rounded.

The thorax consists of nineteen rings; axis convex, tapering, and rather narrow, being about a third less than the width of the pleuræ (including spines) anteriorly, whilst posteriorly, for the last six or seven segments, it is scarcely half as wide, the pleuræ having increased in length, whilst the axis has been gradually tapering. The pleuræ are compressed and deeply grooved obliquely to a little beyond the base of the spines; the upper fourteen terminate in short spines, which turn abruptly backwards, and at about the same angle. In the hindmost pleuræ the spines are somewhat lengthened, but are still very short indeed for this genus, and are exactly like the two front pleuræ of the tail. The latter is composed of two nearly free segments, with short spinous pleuræ (fig. 5), and an appendix, which is almost circular and has one pair of lateral ribs only. It has a broad axis, marked by five annulations, the hinder one being much elongated, and indented slightly along the middle of its length. The limb of the broad circular appendix (fig. 6) is quite distinguished from the two front pleuræ, and is depressed, and marked by two furrows, which terminate in the wide margin. The upper pleuræ are grooved nearly to their tips. Margin of limb strongly marked, and somewhat raised.—H. Hicks.

The close observer can hardly fail to be struck with the sort of intermediate character borne by this species. It reminds us almost equally of *Paradoxides* and *Anopolenus*. The shortened spines to the body and tail, the long, narrow, and strongly margined eye, the transverse, equal, parallel side-lobes of the glabella, the distinct anterior margin to the head (on the young specimens at least), the squarish, not wide, truncated labrum, and the compound tail, all tend to connect this old species, first with such further-developed forms as the *Anopolenus* (?) or *Paradoxides Loveni*, Angelin, of Sweden, and, through them, with *Anopolenus* itself.

In speaking of the compound tail, I would not be too confident that the two pleuræ really form part of it. But we cannot deny that several of the species really have a pair of long-spined pleuræ attached to the upper border of the tail itself, though their connexion with the rounded or squarish appendix is not evident in general. In

Quart. Journ. Geol. Soc. Vol. XXV. Pl. IV.



ontal Scale :Bedford S^t. Covent Garden.

Fig 1 SECTION FROM QUAKERS YARD JUNCTION TO ABERDARE JUNCTION (SEE PLATE V)

Vertical Scale Nº 1 Section. 0 50 100 200 300 400 feet

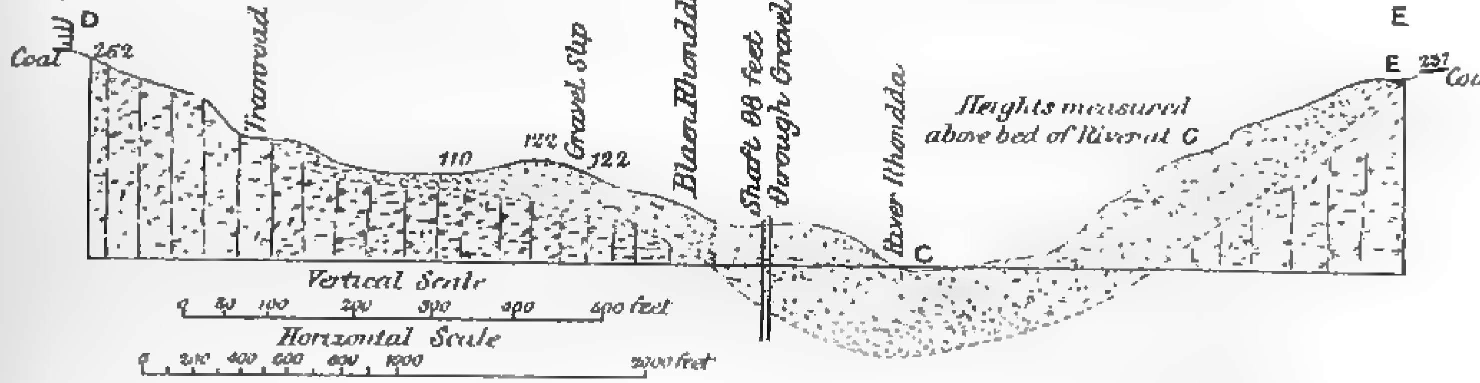
Nº 1 Section – Horizontal Scale same as Vertical between A and E; between E and G the Horizontal Scale is one fourth the Vertical.

To illustrate Memoir on the
QUATERNARY GRAVELS
BY ALFRED TYLOR, F.G.S.
1868-9.

Gravel with rolled Stones		
Sandstone Rock		
Flint Gravel	e	
Brick Earth and Laminated Beds	c	
False Bedded Sands	d	
Thanet Sands	b	
Chalk	A	

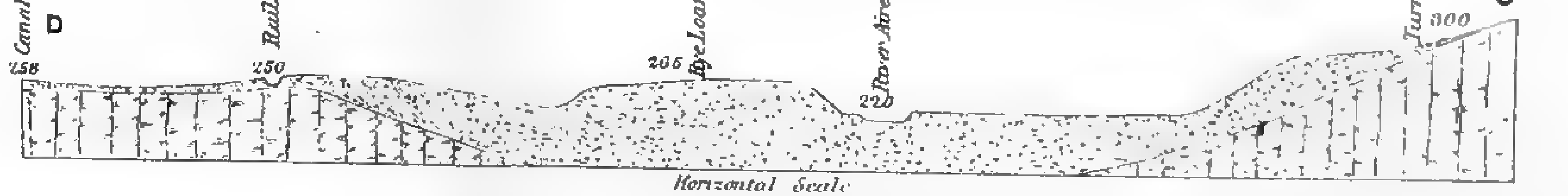
The Heights in Figs. 4, 5, 6 & 7 refer to ordnance Datum.

Fig 3
CROSS SECTION OF RHONDDA VALLEY, S. WALES.



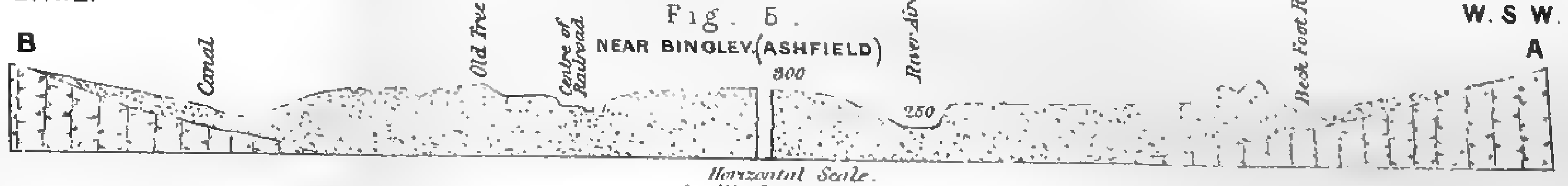
Vertical Scale 0 50 100 200 300 400 500 feet
Horizontal Scale 0 200 400 600 800 1000 2000 feet

Fig. 4 SECTION NEAR COTTINGLEY BRIDGE, BINGLEY.



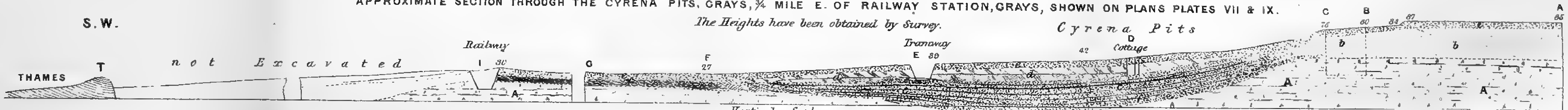
Horizontal Scale 0 100 200 300 400 feet
Vertical Scale 0 50 100 150 200

Fig. 5 NEAR BINGLEY (ASHFIELD)



Horizontal Scale 0 100 200 300 400 500 feet
Vertical Scale 0 50 100 150 200 250 feet

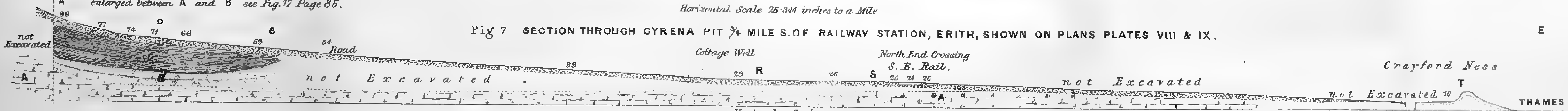
Fig. 6.
APPROXIMATE SECTION THROUGH THE CYRENA PITS, GRAYS, ¾ MILE E. OF RAILWAY STATION, GRAYS, SHOWN ON PLANS PLATES VII & IX.
The Heights have been obtained by Survey.



Vertical Scale. 0 10 20 30 40 50 100 150 200 250 300 feet
Horizontal Scale 25·344 inches to a Mile

Fig 7 SECTION THROUGH CYRENA PIT ¾ MILE S. OF RAILWAY STATION, ERITH, SHOWN ON PLANS PLATES VIII & IX.

(This Section has been also drawn enlarged between A and B see Fig. 17 Page 85.

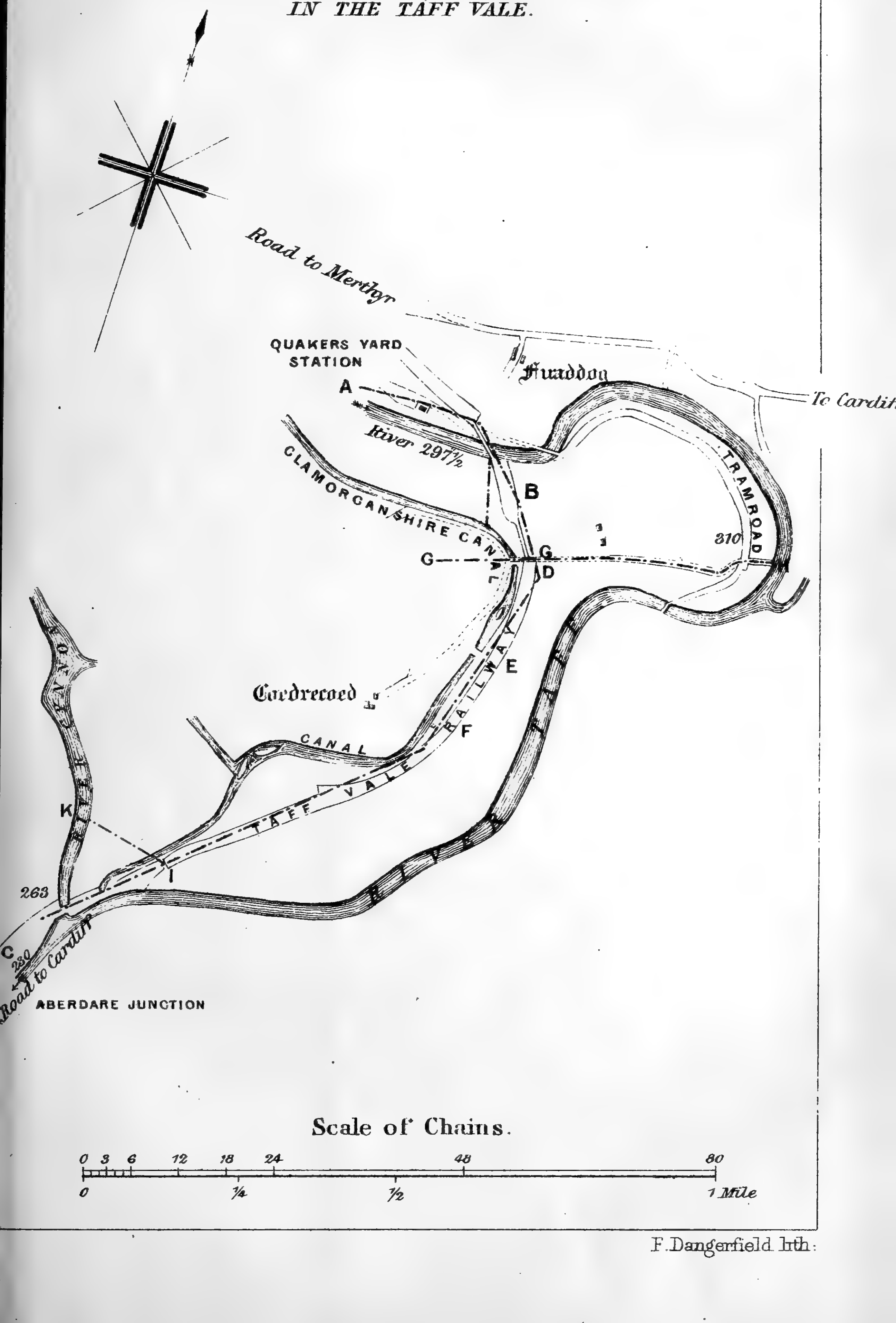


Vertical Scale. 0 10 20 30 40 50 100 150 200 250 300 feet
Horizontal Scale 25·344 inches to a Mile.

F Dangerfield lith Bedford St Covent Garden.

PLAN SHEWING LINES OF SECTION

IN THE TAFF VALE.



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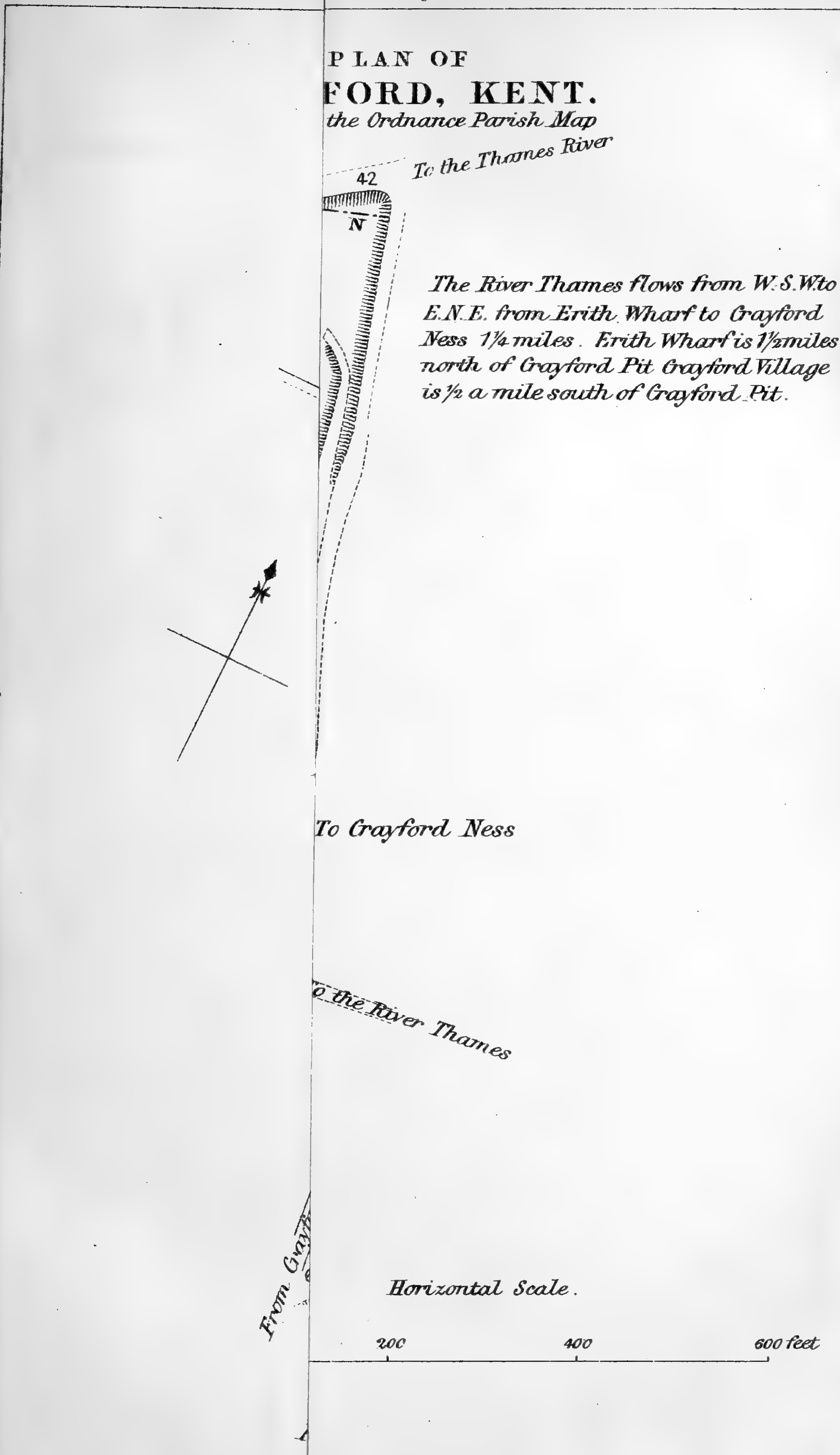

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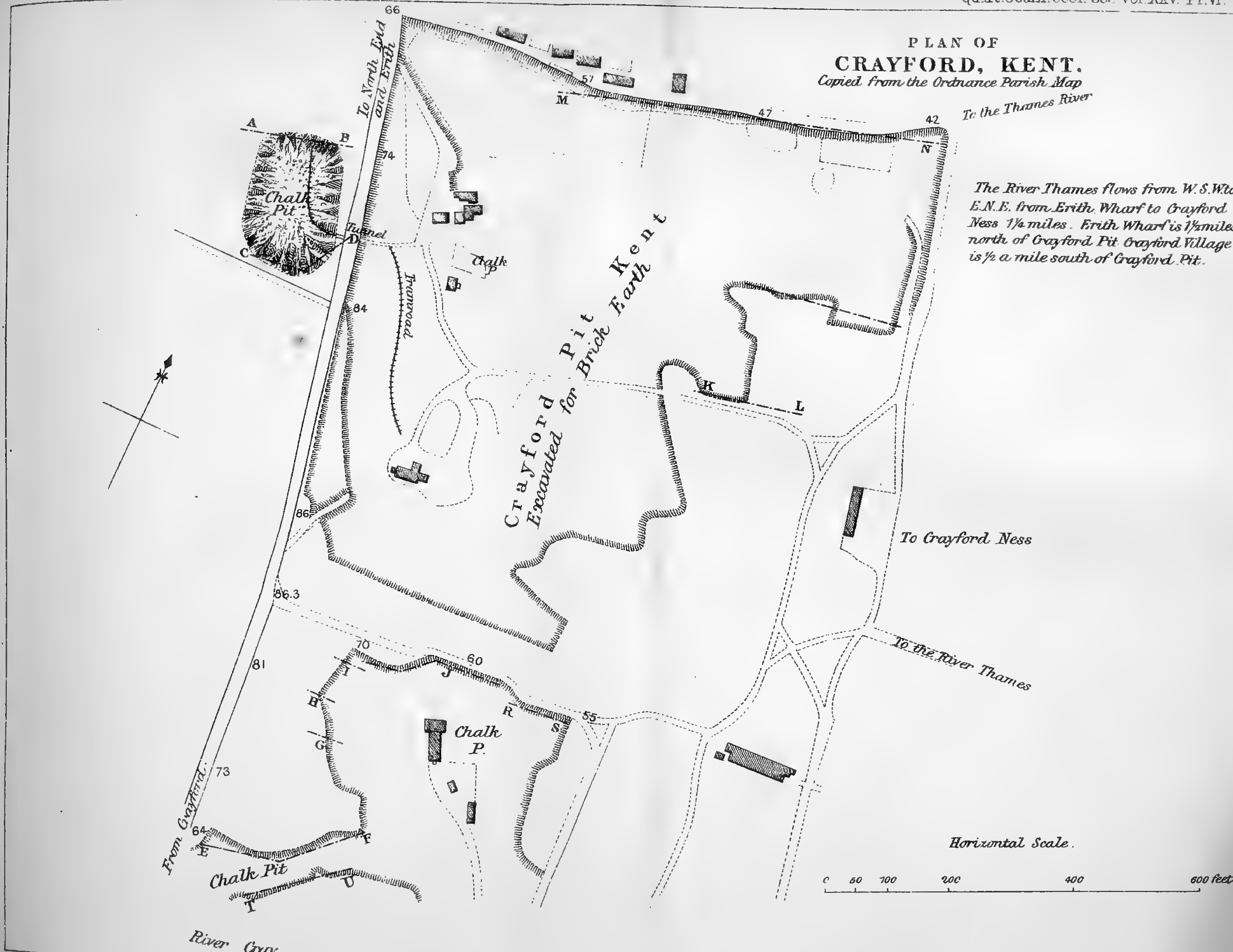

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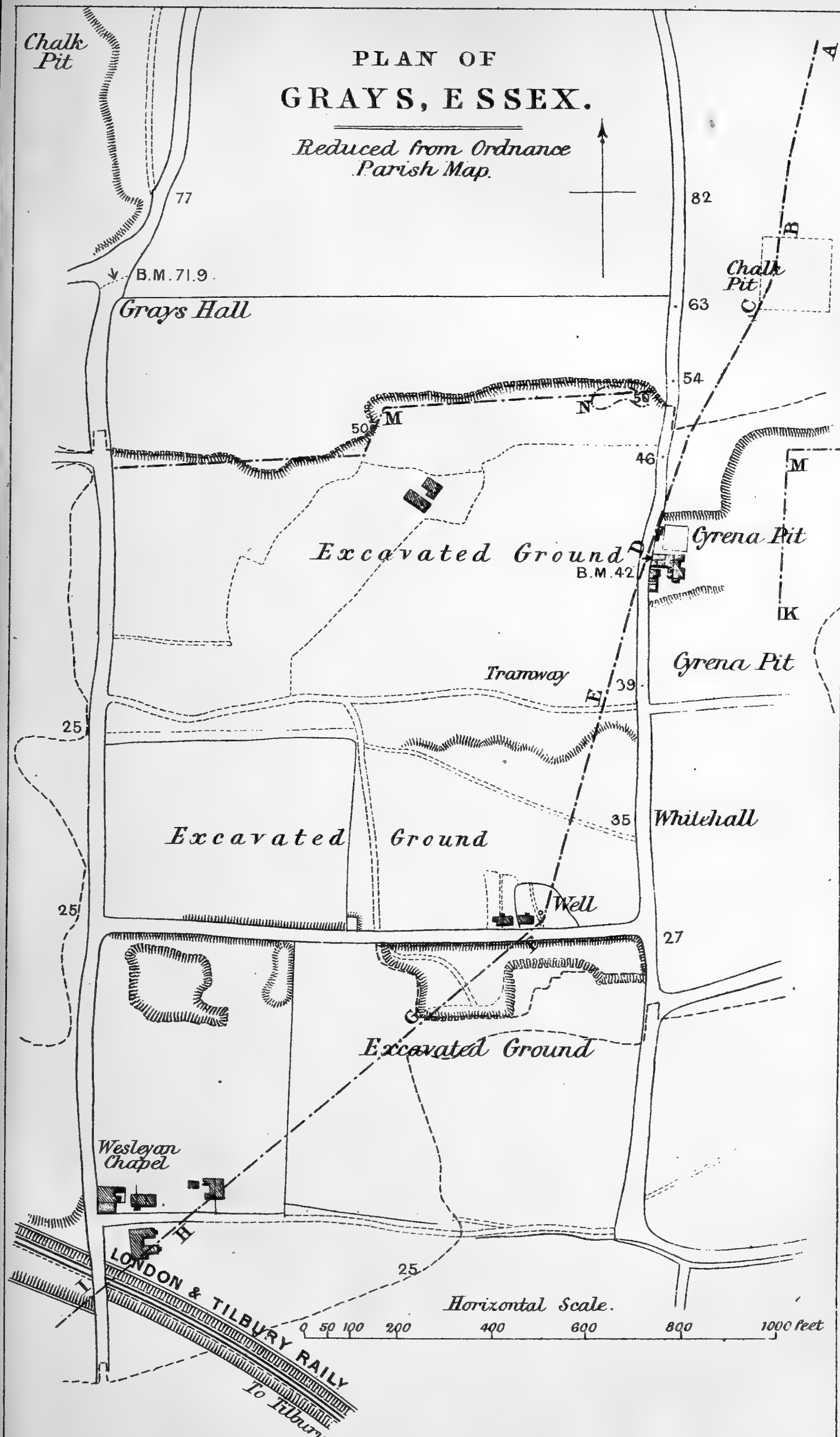

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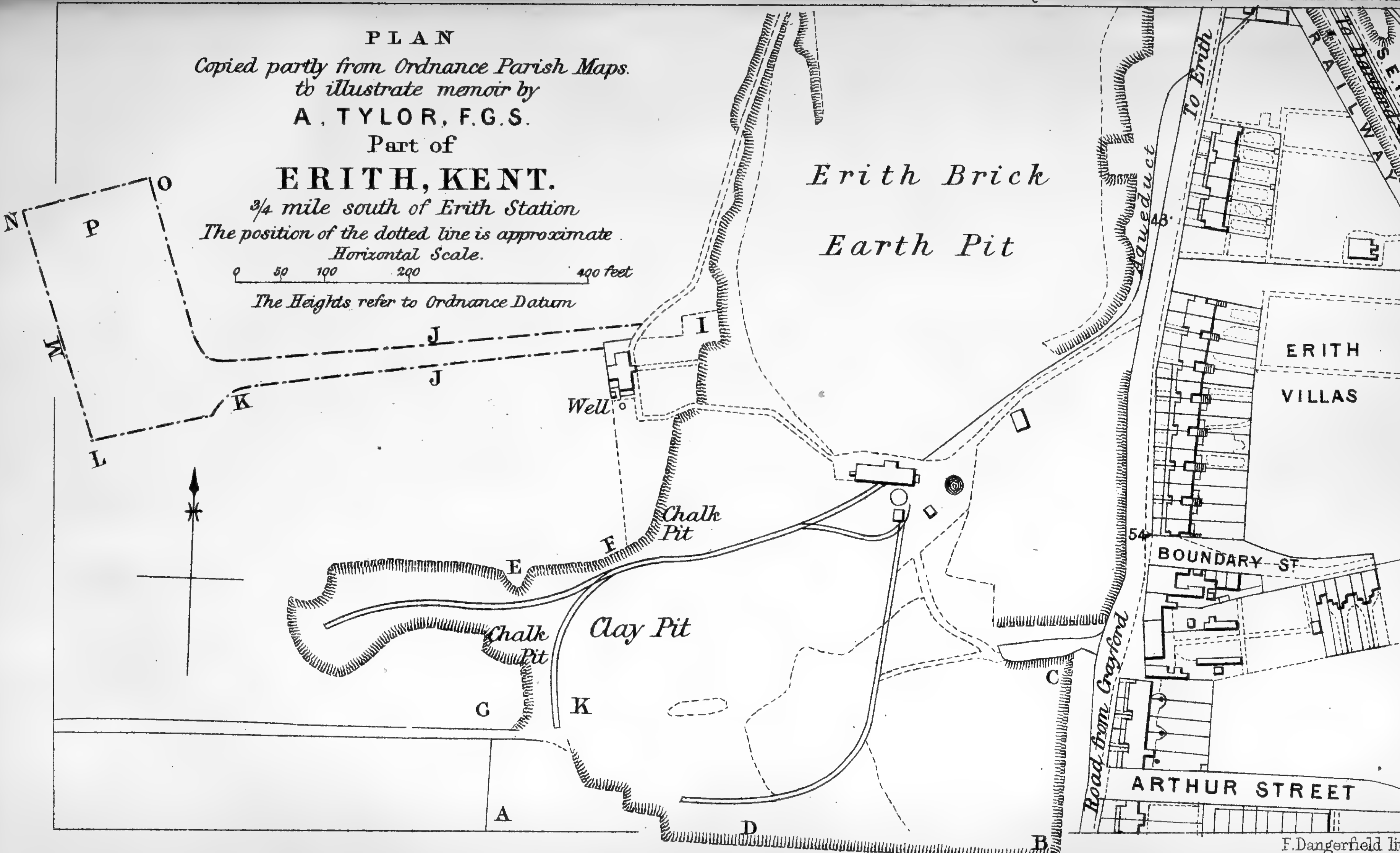


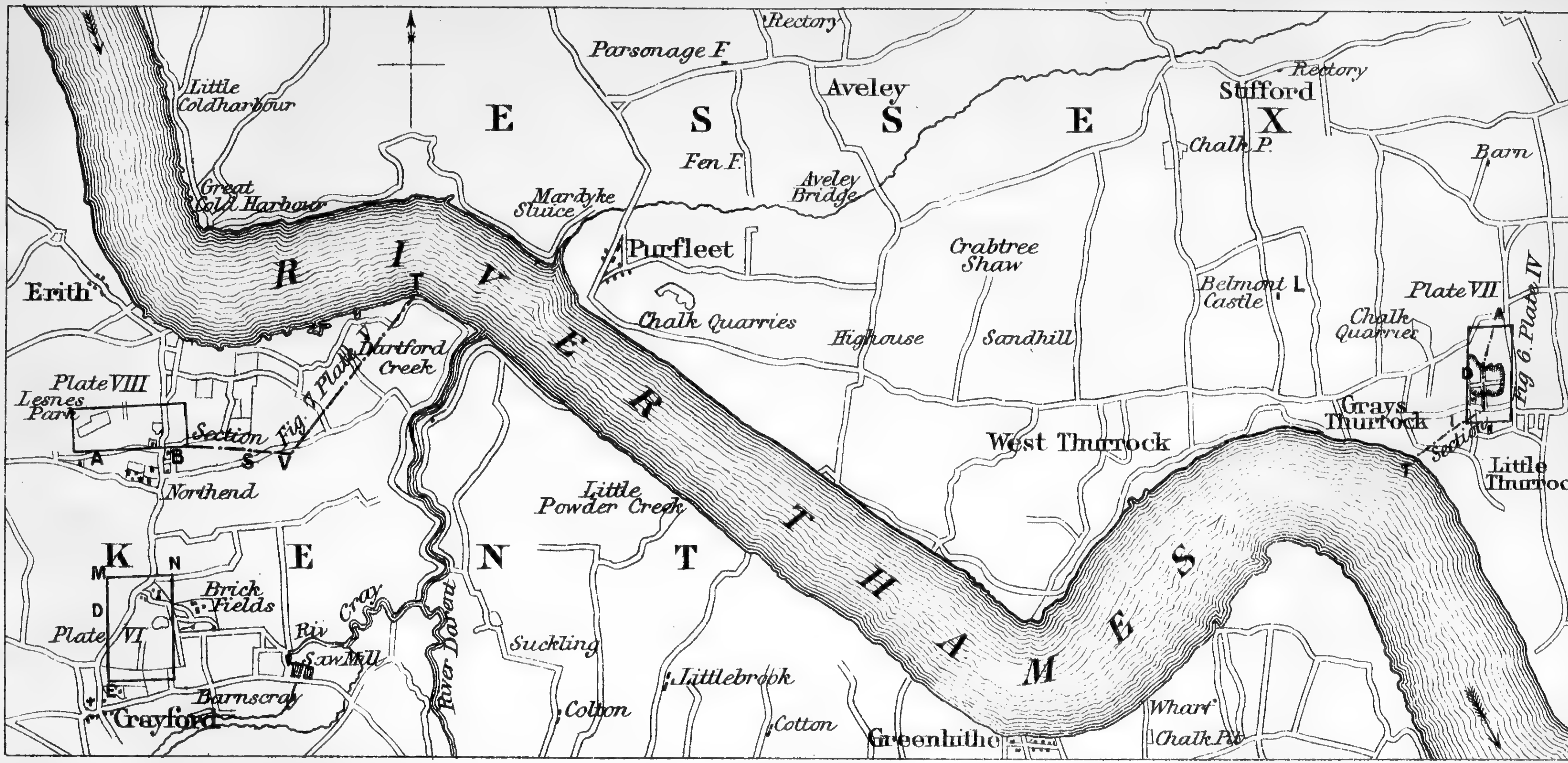
F. Dangerfield lith

MAP

To illustrate Memoir by A. Tylor F.G.S.

PART OF KENT AND ESSEX.

Key showing position of Plans, Plates VI. VII & VIII– and the River Thames.



F. Dangerfield lith

Scale 1 Inch to a Mile.

our former paper * on the great *Paradoxides* such pleuræ were described of great length. In the present species they are shorter, but still appear to be distinctly separated by simple grooves from the circular appendix as in *P. Davidis*. In *P. Loveni* they are perfectly soldered, and are indicated only by the increased number of lateral grooves and marginal spines of that fossil; and in *Anopolenus* also the limb is many-ribbed and the margin spinose.—J. W. S.

EXPLANATION OF PLATES II. & III,

(*Illustrative of Fossils from the Menevian Group.*)

PLATE II.

Figs. 1 & 2, 4 & 5. *Conocoryphe applanata*, Salter. Natural size.
3. —— *perdita*, spec. nov. Natural size.
6. Embryo of *Conocoryphe applanata*. Magnified.
7. *Conocoryphe humerosa*, Salter. Natural size.
8. —— *bufo*, Hicks. Natural size.
9–12. *Paradoxides Aurora*, Salter.

PLATE III.
Paradoxides Hicksii, Salter.

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4. *On* QUATERNARY GRAVELS. By A. TYLOR, F.G.S.

(Read May 6, 1868 †.)

[PLATES IV.–IX.]

IN continuation of a paper on this subject in the Quart. Journ. Geol. Soc. vol. xxiv. p. 103, I now submit a number of measured sections selected as instances of the deposition of gravels of different character under different circumstances both of height above the sea-level and distance from the sea.

The illustrations and remarks in this paper relate to the unfossiliferous gravels of the rivers Taff, Rhondda, and Cynon, in Glamorganshire, South Wales, to those of the Aire, in Yorkshire, and to the fossiliferous gravels and brick-earths of the lower part of the Thames and Lea rivers, in the counties of Kent and Essex.

One section of the fossiliferous gravel of the river Avon, at Salisbury, is given for the purpose of comparison with those of the Thames; and a section across the valley of the Aire, in Yorkshire, is compared with those in the valleys of the Taff and Rhondda.

A map of part of Glamorganshire, and a longitudinal section of the bed of the river Taff, with the heights along its course measured above the height of spring tides at Cardiff, have been prepared to define the exact locality of the Welsh gravels alluded to. A similar map and sections of the course of the river Aire, in Yorkshire, with heights measured from the Ordnance datum, are given for comparison with the Welsh illustrations.

A sketch-map of part of the river Thames, and of the adjoining

* Quart. Journn. Geol. Soc. vol. xx. p. 235, pl. 13. f. 2.
† For the Discussion on this Communication see Quart. Journ. Geol. Soc. vol. xxiv. p. 456.

counties of Kent and Essex, and separate maps, on a large scale, of the Chalk-pits and Brickearth-pits of Erith, Crayford, and Grays define the exact position of the sections across the valleys of the Thames and in the pits; and the heights explain their relation to the present river Thames. Sections of the raised beach and mammaliferous gravel at Brighton, and of the fossiliferous gravel and raised beach at Sangatte, showing the contour and the modelling of the upper surface of the gravel-series, have been also drawn. A comparative Table of fossil shells &c. from the above localities is also added.

The evidence of numerous sections teaches us that, prior to the deposition of the gravel, there was a land-surface smoothly denuded by rain and streams so as to form a perfect system of principal and minor valleys, the ground sloping from higher to lower points, so as to admit the rainfall to flow with the minimum of obstruction into the side-valleys and thence into the ancient Thames. The subsequent deposition of the gravel-series did not in any way alter old lines of drainage; but where concavities existed the new deposit had a tendency to fill them up with a thicker stratum of material than was spread over the general surface of the chalk or clay. Thus the Quaternary beds reach a thickness of 80 feet at the maximum, while the average is perhaps only 25 feet in the whole district. Some boulders on the upper part of the gravel-deposits reach to many tons in weight; and they are as large or larger than those in any part of the series, so that there is evidence of as great intensity of pluvial action at the end as at the commencement of the Quaternary series.

Except where the old river-channels and concavities are filled up, the contour and the modelling of the upper surface of the gravel-series resembles that of the clay or chalk on which the lower gravel rests, and is perfectly adjusted to carry off the rainfall occurring in the later part of the gravel-period into the ancient Thames without any impediments. The contour of the land is such that it could only have reached its present form by pluvial and fluvial action, and not by marine denudation. Many of the minor valleys in which gravel and brick-earth were deposited with each flood in the Quaternary period are now dry. After the heaviest rainfall in recent times there is not sufficient force of water to remove vegetation, so as to make any change in the present surface.

We are therefore justified in stating that the character of the denuded surface of the London Clay and Chalk above the level of the Thames is evidence of the occurrence of an enormous rainfall in the commencement of the gravel-period, and that the character of the surface-deposits of gravel is evidence of nearly as much rainfall at the close of that period.

With a rainfall such as we now have, it would be impossible that such widely extended gravel-beds could be spread over an extensive area, and reach to a height more than 150 feet above the level of the Thames. It is equally impossible for the present volume of the Thames to have produced fluviatile beds at all equivalent in size to those of the ancient Thames.

The condition of the beds which rise above the 50-feet level points rather to pluvial than to fluvial action. Of marine remains in the Thames-valley gravels there are no traces.

In the south and east of England the hills are rarely higher than 1000 feet, and the valleys are deep and wide, and are adapted for rivers 20 times as large (or more) as those occupied by them now.

The banks of the old rapid and large rivers are now separated from the banks of the present small streams by a great extent of *remanié* alluvium; and modern gravel has accumulated in the old river-channels, owing to the decreased velocity of the present streams.

This is well shown in the large flat plains of gravel through which the Lea river flows, where the river, even in floods, only reaches the bottom of the 30-feet bank at Clapton, while the brick-earths and gravels of the ancient Lea reach to 80 feet above the level of the present stream.

Some modern streams have still force enough to cut horse-shoe bends and new courses out of the flat plains which were probably in flood-times constantly overflowed by the old rivers running in the gravel-period; but the covering of recent alluvium in the river-channel prevents any observation of the character of the gravel itself.

Large and deep side-valleys open into the Thames valley, containing small streams or rivers; but I do not know of any instance of a stream in this district having risen high enough, or had force enough, to cut through any of the Quaternary deposits, so as to expose a good natural section.

The absence of such natural sections is of important geological interest; for it is evidence that no marked changes of level occurred during the gravel-period. If elevations of the land had occurred during the latter part of the gravel-period, as has been supposed, and rivers had cut down these beds 30 or 40 feet, then all the side-streams would have had to adjust their beds to the new circumstances of level, and we should have had natural sections in every side-valley, as well as in the Thames valley itself. There are no waterfalls in the district; and every stream reaches the main river by a very gradual course in obedience to a definite law.

The fact that no good natural sections of this kind exist in the Thames valley, or in the valleys of its tributaries, is a proof that neither the principal river nor its confluent streams had force enough to break through the upper gravel and to expose the brick-earth and sands below. It is also evident from the same facts that the change in rainfall, and consequent decrease in volume and speed of all rivers and streams in the district, occurred immediately after the close of the gravel-period.

We find natural sections of gravels along the water-courses of the streams and rivers of South Wales, where the rainfall is still nearly 40 inches, and the side-streams fall with great rapidity to the main rivers from the high land. The materials of these gravels are essentially different from those of the south and east of England; and although the two sets of gravels may be identical in age, there would be as much relative difference between the deposits in high and low districts in the gravel-period as there is now. I have introduced illustrations of these Welsh gravels, because it would be impossible to form any clear view of the general features of the gravel-period without comparing the sections of the deposits found on the upper part of rivers flowing off high land with those formed along the lower parts of rivers near the sea in the Quaternary period. The general law of deposition will be the same; and it is this law I wish to investigate by the aid of the measured sections. Those sections are chosen specially for description where the rock or clay and the incumbent gravel can be observed together. This gives an opportunity of observing the points or lines on which denudation ceases and deposition commences.

In the London basin, the series of Quaternary strata generally commences with a coarse gravel, a few feet thick, eating into the chalk or London clay in which it lies, and mixing up the clay or chalk with the gravel.

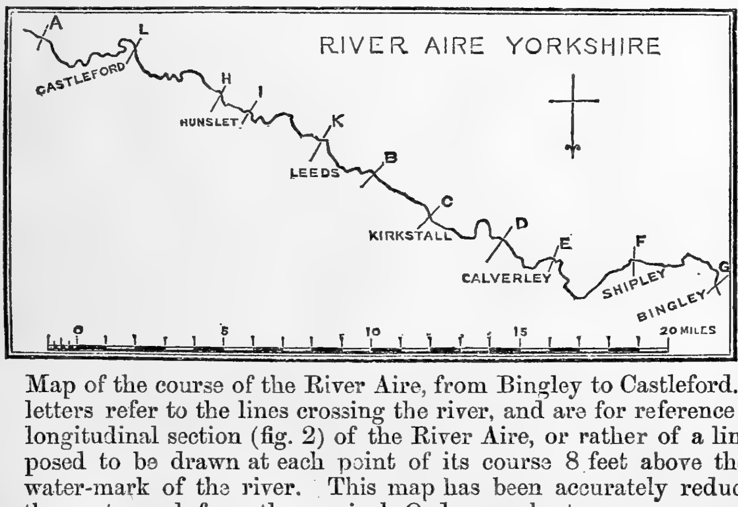
The coarse gravel often passes into coarse sand, and is evidence then that the movement of the water at that point was not sufficiently rapid to transport gravel, or that there was no gravel present to be deposited at that moment.

I have not observed any finely bedded clay or loam in contact with the surface of the chalk or London clay in the London basin; and this appears as if the movement of water over the surface of the clay and chalk had been generally rapid at the commencement of the Thames deposits. No doubt there are many cases where the first deposit has been of fine materials, but I have not been able to meet with them.

Where concavities in the chalk and London clay exist in the neighbourhood of the Thames, and in its side-streams, and are so situated as to be favourable for quiet deposition, the lowest bed of gravel or coarse sand sometimes contains fossils derived from the Eocene beds, and rolled Mammalian remains of a later period. It is succeeded by a series of laminated clays and false-bedded sands, from 20 to 30 feet in thickness, with water-worn materials, and containing fluviatile and land shells, tranquilly deposited with Mammalian remains (only occasionally rolled). No natural sections exist of this class of deposits; but excavations for brick-earth have during the last 30 years opened out several of these fluviatile beds.

Non-fossiliferous gravels are often clearly contemporaneous with these fluviatile brick-earths. If on the same horizon, they are sometimes interstratified with the fossiliferous beds; but the non-fossiliferous gravels reach to much higher levels, and are deposited at much steeper angles, and contain materials not perfectly washed or water-worn. They include masses of Thanet sands, of plastic clay, of London clay, and of the fossiliferous bands of the Woolwich series, buried in great unrolled masses in the gravel, as well as water-worn masses of Druid Sandstone, derived from strata very near the spot of deposition. These materials were evidently washed in by heavy floods, not confined to the valleys, but passing over the whole surface of the land, tearing up the ground and carrying it to lower levels into the valleys. At page 124, Quart. Journ. Geol. Soc. vol. xxiv., I described such a flood in Sind in the year 1866, when a rainfall of 24 inches occurred in ten hours, laying all the surface of the land under water, and moving very great weights a considerable distance. The ancient river-deposits of the Thames basin associated with this flood-borne detritus are generally covered by an upper bed of well-rolled gravel, not exceeding 10 feet in thickness. This bed is often only 3 or 4 feet thick, and lies on the frequently eroded surface of the stratified brick-earths and clays of the middle part of the Thames Quaternary series. Even when for a short distance this surface-bed contains few pebbles, there is no difficulty in identifying it; for it will soon be charged again with pebbles. This thin upper coating of well-rolled pebbles, enclosed often in a stiff brown clay, but sometimes in sand or loess, extends from the river-banks to near the tops of the hills over all the other parts of the series of gravels, and often over the London clay and chalk; it covers a most extensive area, forming a marked contrast to the middle series of laminated brick-earth, false-bedded sands, and stratified clays, which are more confined to the low levels near the rivers or brooks. This bed of upper clay and pebbles slopes to the lower ground (I estimate on an average) at 1 in 260, and falls therefore about 20 feet in a mile. It is washed over the surface of the land smoothly, removing all abrupt heaps of gravel, and leaving no greater irregularities of the surface in the London basin than occasional low terraces. The smoothness and perfect manner in which the gravel is deposited is shown by the fact that the surface of the London clay or chalk is covered, notwithstanding inequalities of the surface, by a bed only 25 feet thick over such a large district.

Fig. 1.—*Map of part of the course of the river Aire, Yorkshire.*



Map of the course of the River Aire, from Bingley to Castleford. The letters refer to the lines crossing the river, and are for reference to the longitudinal section (fig. 2) of the River Aire, or rather of a line supposed to be drawn at each point of its course 8 feet above the full-water-mark of the river. This map has been accurately reduced by the pentagraph from the one-inch Ordnance sheets.

The river Aire rises near Malham Tarn, in Yorkshire, in the Carboniferous Limestone, one branch coming from a cave near Gordale Scar, then flows over the very thick formation of Millstone-grit, reaches the Coal-measures between Shipley and Bingley, and, passing over the Magnesian Limestone and the New Red Sandstone, empties itself into the Humber, or a branch of the Humber, near Goole. The valley-gravel at Leeds is famous for the fine remains of Hippopotamus found in 1852. The bottom of the valley through which the Aire flows is from one-half to one and a half mile wide, and is coated over with a deposit of gravel and rolled boulders of unequal thickness and elevation, consisting principally of limestone at the upper part near Malham and Skipton, and of Millstone-grit and sandstone near Leeds, with some limestone boulders. The Bingley gravel consists of Millstone-grit, sand, rock, and limestone in large percentage. Some boulders of limestone are found near the mouth of the river near Goole; but at Bingley, fourteen miles from Skipton in a direct line, they form a considerable percentage of the whole gravel. Until the Leeds and Liverpool Canal was made between Leeds and Skipton, this valley-gravel was turned over for the purpose of removing the limestone boulders for burning into lime. There are numerous remains of old limestone-quarries and lime-kilns at Bingley, although it is ten miles from the nearest limestone rock.

Fig. 2.—*Map of part of the river Aire.*

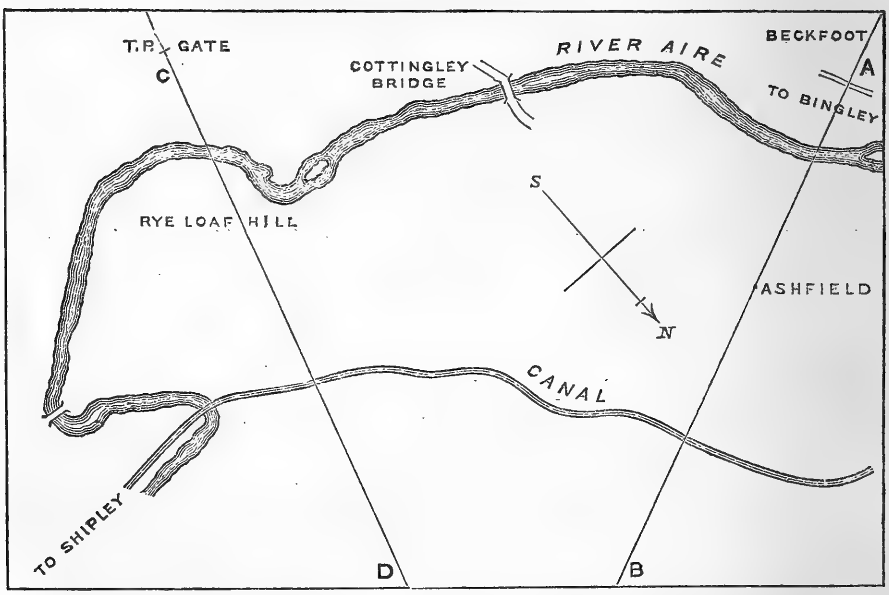


Fig. 2 is a plan of the Aire valley between Bingley and Shipley, showing the lines of sections A B and C D from the sandstone-rocks on each side of the valley. (See Pl. IV. figs. 2 and 3, for details of the sections; and to these I will now refer.)

The section (fig. 4, Pl. IV.) through Ashfield, half a mile east of Bingley, exposes a thick gravel- and boulder-deposit, forming what are called the Old Hills. This gravel has been worked over for the blocks of limestone it contains, leaving an irregular surface.

The gravel is 50 feet above the river Aire in the thickest part; and no rock has been met with to prove how much lies below the level of the river-bed; but the town surveyor, who has carried out the drainage of that town, informs me that the rock is probably from 30 to 40 feet below the level of the river.

Considering the width of the valley, nearly three-fourths of a mile, we might estimate the gravel over a width of 1000 yards to be of an average thickness of 20 yards; 20,000 yards at a weight of $1\frac{1}{2}$ ton to the cubic yard, is 30,000 tons; there would be then 30,000 tons of rock and gravel to each yard run, or about 53 million tons of gravel to each mile of river, supposing the section, fig. 3, at Bingley to contain the average amount of gravel in that valley.

This quantity of 53 millions of tons of gravel per mile is apparently not out of proportion to the power and dimensions of a river able to flood its valley to a height of 50 feet over a surface a mile wide with a gradient of from 3 to 10 feet per mile.

The escarpments, or gravel-banks, 50 feet high and 200 yards wide, in fig. 4, appear to mark the ordinary limits of the ancient river, as the sides of the gravel-bank are laid in many parts in the form of a steep escarpment sloping to the current at an angle of from 25° to 35°, while the top of the gravel-bank is flat, except where it is hollowed out by another part of the river-channel more or less deeply. A bank of 10 feet above the Aire is sufficient now to retain the water, except in the heaviest floods. Contrasting the floods of this river at the present time with those in the period when the gravels were deposited, it would appear that a flood-line of 10 feet now replaces one of 50 feet. The cubes of these flood-lines would probably represent the proportion of the volume of water flowing down the valley in the two cases. Then 10^3 is to 50^3 as is 1 to 125. The volume of water would on that hypothesis now be only the $\frac{1}{125}$ of that in the gravel-period.

Section (Pl. IV. fig. 5) along the line C D, through Rye-Loaf Hill, one mile E.S.E. of Bingley, shows the outline of the gravel-deposit lying on Carboniferous sandstone and shales. This part of the Aire gravel, along the line C D, reaches also to a height of 50 feet above the present level of the river; it does not appear to have ever been worked for limestone, and is about the same height above the irver Aire as in A B. The escarpment of the gravel at Rye-Loaf Hill is well marked, and slopes to the river at 25°; the top is flat, and the form such as could only be produced by a river occupying during floods the whole width of the valley, the water rising at least 50 feet above the present flood-level. The limestone boulders forming a large portion of the Bingley gravel are so well rounded that they indicate long-continued rolling in a river-channel.

There is a swamp to the east of Bingley church, in which remains of oak-trees have been found in peat, and below the surface a stratum of freshwater shells of existing species, according to my informant. This part of the section appears to be identical with the Hippopotamus-bed at Leeds.

Mr. A. Harris, jun., of Ashfield, found, in 1868, pieces of rolled chalk several inches long below the peat, during an excavation made for foundations of a chimney. This chalk may have fallen into fissures of the limestone during the denudation of the Cretaceous series, and have been washed out again at a comparatively recent period.

The quantity of gravel now left in the valley of the Aire may only represent the portion of water-rolled débris arrested *in transitu* to the sea, at a period when there occurred atmospheric changes of a character and importance sufficient to reduce the flow of water to its present insignificant amount.

My object in selecting the gravel-deposit of the river Aire as an illustration for examination is because that river flows over a variety of distinct strata, and yields evidence of the transport of a number of large boulders from its source to near its outfall. Then its source is in a district in which occur the celebrated caves of Kirkdale, so rich in the large Mammalia, such as Elephant, Rhinoceros, Hippopotamus, and Hyæna, and containing in the upper part of the cave-deposits human skeletons and pottery.

Although at Bingley itself no Mammalian remains have been noticed, yet at Leeds, twelve miles lower down the river, the following description of the discovery of *Hippopotamus* sufficiently identifies the Leeds gravel with the cave-gravel of the limestone district by means of its organic remains, and with the Bingley gravel by means of mineral character and stratigraphical position.

Mr. H. Denny, of Leeds, records the discovery, on the 3rd of April 1852, of great portions of the skeletons of two or three large specimens of *Hippopotamus major* at the angle formed between the river Aire and Wortley Beck, close to Holbeck Station, Leeds, at a height of 115 feet above the sea, and 20 feet above the banks of the Aire.

Mr. Denny writes, ('West Riding Geological Society Reports for 1854,' p. 325):—"The bones were discovered in a dark-blue sedimentary clay almost approaching mud, and appear from their condition to have belonged to animals which had lived and died in the immediate vicinity, and were subsequently drifted, together with fragments of trees to the bottom or lower part of a swamp, found only in this particular bed of clay, confined to one portion of the field; but the clay becomes much thicker, and reaches 10 feet in thickness as it approaches this spot, thus clearly indicating it to have been lower than the remainder of the brickfield."

Beds of clay of variable quality resting upon gravel, with occasionally large boulders, some of which contain impressions of *Stigmaria* and fragments of trees to the depth of 10 feet, yielded the bones of three individuals of *Hippopotamus major*, whose skeletons seem to have been complete when deposited. The canine tusk of one individual was 18 inches long, by $2\frac{1}{4}$ broad. Mr. Denny observed that the vertebral column of one Hippopotamus extended in a line across the trench; the ribs appear to have been *in situ*; and from its position he considered that the animal had been lying on its side. Portions of the *Elephas primigenius*, with molar teeth, and fragments of *Urus* were also met with in the Wortley Beck Fields closely adjoining.

Section at Holbeck.

Greyish sandstone	2 feet.
Yellow sand..	2 feet.
White sand with well rolled boulders of grit and sandstone, with an occasional fragment of limestone and chert..	thickness unknown.

Mr. Filiter, the engineer of the Leeds Waterworks, informed me that the exact position where the remains were found was 53° 47′ 42″ N., 1° 34′ 10″ W.

It is uncertain whether the Aire-valley gravel represents exactly the beginning of the series of the Kirkdale-cave deposits; but the discovery of the Hippopotamus 10 feet below the surface of the gravel, and only 15 feet above the present level of the Aire, clearly proves that the great mass of the Bingley accumulations was anterior to the time at which the Leeds Hippopotamus lived. If the upper series of these Bingley gravels represented in time the last deposit of 10 feet at Leeds, they would be of the same date as the Hippopotamus, and all the lower part of the gravel at Bingley below the 10-feet level would be older than the Hippopotamus.

In fig. 2, plan of the course of the river Aire between Bingley and Shipley, a curve not very remote from the horseshoe-form is seen.

The section of the river-banks at many points near this curve (see Pl. IV. figs. 4 & 5) present steep escarpments to the river, and thus preclude any supposition of glacial or marine action, as neither sea nor glacier could arrange heaps of gravel with a regular slope facing a river following its course in a horseshoe curve.

When we find a set of gravels in the valleys of other rivers deposited in slopes and levels in a similar manner, and bearing close comparison in contour, condition, mineral contents, dimensions, and position with the mammaliferous gravel of the Aire, it may be safely inferred that we are examining valley-gravels of the same date as that of the Aire, although Hippopotamus and Elephant may not be found in every river-deposit.

The discovery of Hippopotamus in such a nearly perfect and unrolled condition in the superficial deposit of the river Aire, at Leeds, was a most fortunate thing for geologists who discuss the later Quaternary deposits, as it shows that the range of the extinct Mammalia extended to a time since which there have been no changes of importance in the level, nor disturbance, of the superficial deposits in Yorkshire.

At Cottingley Beck, near C, fig. 2, there is a natural section of gravel resting on shale and clay, and containing a block of sandstone moved from a distance. It is 12 feet long, and of very great weight, and only 6 feet from the surface. This could only have been transported down the small valley occupied by Cottingley Beck by a very heavy flood, and is an indication of the amount of rain which must have fallen at the date of the accumulation of the Aire-valley gravels.

Similar animal remains to those at Leeds have been found associated with the works of man near Bedford, Abbeville, Salisbury, and other localities, so that we are enabled to correlate the gravel of the river Aire with that of a number of rivers which appear to have risen in times of floods from 40 to 80 feet above their present ordinary level in that part of the Quaternary period which I term the "Pluvial period" (Quart. Journ. Geol. Soc. vol. xxiv. pp. 105, 120).

The *Cyrena fluminalis* or *consobrina* is found in the gravels abundantly at St. Valery, at the mouth of the river Somme, in Picardy, and also in the estuary of the Humber at Kelsey Hill. The Aire flows into the Humber.

There is, as might be expected, great difference in the materials of which the respective gravels are composed, arising from the different character of the rocks over which the rivers flow, and from the greater fall of the Aire in its course, from its source to the sea, than that of the Somme. The important stratified valley-gravel at Abbeville, containing numerous species of shells, is represented by the Kelsey-Hill and Hessle beds near the mouth of the Humber at a similar height above the river. The width of the valleys is not so different as their depth; but this is due, as before stated, to the difference in the fall of water per mile in the two rivers Somme and Aire.

There is no good section of gravel now open at Bingley. The limestone boulder-pits have been filled up many years; and the railway is carried near the present river, or in an old secondary river-course of the gravel-period.

Glamorganshire Gravels.

I shall now describe some measured sections of very thick and important river-gravels in the valleys of the rivers Taff, Rhondda, and Cynon, in Glamorganshire, South Wales.

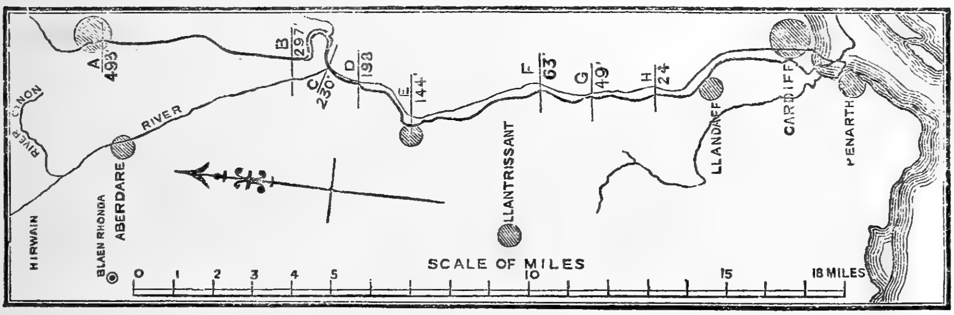
A longitudinal section of the river Taff would show the rapid character of the river, which falls nearly 500 ft. between Merthyr Tydvil (A, fig. 3) and the sea at Cardiff, about twenty miles. The following heights of the bed of the river Taff, above the coping of Bute Dock, Cardiff, were kindly furnished me by Mr. George Fisher, Engineer in chief, Taff-Vale Railway. These heights were the only ones sent to me relating to the river Taff. Their exact position on the map was also laid down by Mr. Fisher himself, and fig. 3 is a carefully reduced copy of his map. The coping of Bute Dock is 9·82 ft. above the level of ordinary spring tides.

Plate V. is a plan of the river Taff, near Quaker's-Yard Junction. Pl. IV. fig. 1 represents a long section opened out by the Taff Vale Railway (ABC), the position of which is shown on the plan (Pl. V.). The heights at different points have been kindly determined by Mr. L. T. Lewis, F.G.S., of Aberdare, or by Mr. G. Fisher, of Cardiff, and are marked on the section.

The plan and section of the valley of the Taff, between Quaker's-Yard Junction and Aberdare Junction of Taff Vale, represent about one mile in length by two-thirds of a mile broad. The height of the point of the sandstone-rock forming the crown of the hills is about 275 feet above the level of the Taff at Aberdare

Junction; the river under the viaduct is 325 feet above the mean level of the tide at Liverpool. The rails of the Taff-Vale line are 96 feet above the Taff at Quaker's-Yard Junction, and 30 feet at Aberdare Junction, so that the rails are laid on a very steep incline of 1 in 50. On the average, between B and C the fall of the rail is 154 feet, and that of the river about 88 feet between the two stations. The rails cross the river on a viaduct about 96 feet high near the upper end of the incline, and on a bridge 30 feet high at the bottom of the incline.

Fig. 3.—*Map of part of the course of the river Taff, Glamorganshire.*



	ft.	
Bed of river Taff near Merthyr Station	493·0	A.
Bed of river at Quaker's-Yard Viaduct	297·50	B.
Bed of river near foot of incline at Aberdare Junction	230·0	C.
Bed of river near junction of river, Clydach	199·50	D.
Junction of river Rhondda at Pontypridd Junction	144·0	E.
Bed of river Taff, at Taff's Well, between Llantrissant and Walnut-tree Junction	63·0	F.
Bed of river Taff at Pentyrch Bridge, between Walnut-tree and Penarth Junctions	49·0	G.
Bed of river Taff at Melengriffith, between Penarth Junction and Llandaff Station	24·0	H.

The section given in Pl. IV. fig. 1 commences at Quaker's-Yard Junction with a bed of loose gravel lying along the sides of the valley, 140 feet high above the river, but probably not of greater thickness than 40 or 50 feet on any part of the rock out of which the sloping sides of the valley are excavated. The gravel is full of very large boulders of the local Carboniferous rock, which is an extremely hard, compact, massive-bedded sandstone of the Pennant series, several hundred feet thick. These boulders are sometimes angular, and sometimes weathered or rolled. There also occur quantities of Millstone-grit, brought ten miles down the valley of the Taff, these being always rolled, and boulders of limestone, with a small but conspicuous percentage of well-rolled pebbles of Old Red Sandstone from the Brecon Beacons and other distant hills. These red pebbles are still more worn and rolled than those of the Limestone and Millstone-grit, the source of which is nearer to Quaker's Yard than the Old Red Sandstone. The matrix is clay and sand derived from the Coal-measures, or from decomposed Millstone-grit.

After passing the viaduct, Pl. IV. fig. 1, the section is continued through a deep railway-cutting, the rails being 80 feet below the surface of the ground, and 112 feet below the adjoining peak of rock at D.

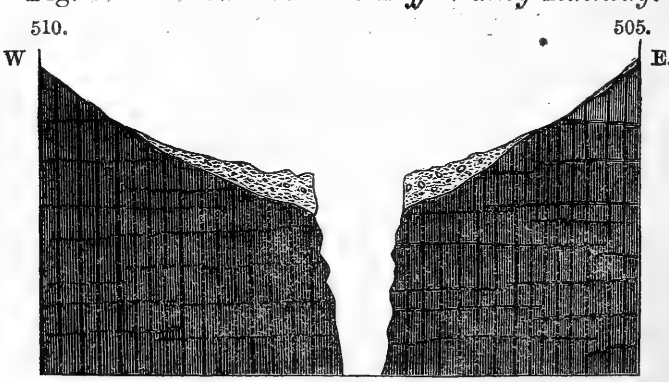
The escarpment of rock is shown to slope about 43° N., at the northern end of the cutting, B, close to the viaduct, and only about 20° at the southern end, D. Gravel with boulders of Old Red Sandstone, and many other rocks, is spread over the surface of the rock at D, up to a height of 200 feet above the river Taff.

Fig. 4.—*Enlarged Section of Gravel Deposit.*

Fig. 4 is an enlarged view of the section at B along the line of railway, showing the gravel lying in a concavity of the rock forming a part of the Taff valley, at very high angles. Near the rock the dip of the gravel is 35°, gradually becoming less steep until it reaches 18°. The gravel below the rails is not exposed at this point. It will be seen that fig. 4 should have been reversed, to accord with Pl. IV. fig. 1; it is on the natural scale.

Fig. 5 is a transverse section at right angles to Plate IV. fig. 1, and fig. 4, showing the railway-cutting at the point D. As it is

Fig. 5.—*Section across the Taff-Valley Railway.*



not sloped, it gives a good opportunity of studying the position of the gravel, particularly as the surface of the rock is clearly exhibited in the centre of the cutting. From this section it is evident that the Taff river flowed at one time in a straight line from near Quaker's-Yard Junction to Aberdare Junction, excavating the small valley shown in fig. 5, before it formed the horseshoe bend shown on the plan (Pl. V.), through which the river now reaches the same point, G; this valley at D is about 40 feet deep, and 200 yards across, and is excavated out of the wedge-bedded pennants, which dip south-east at a small angle, but have both horizontal and vertical joints well marked, dividing the rock into cubical masses at angles varying from 80° to 85°.

The railway engineers have taken advantage of this natural valley, and cut through it to a depth of 60 feet below the bottom of the gravel.

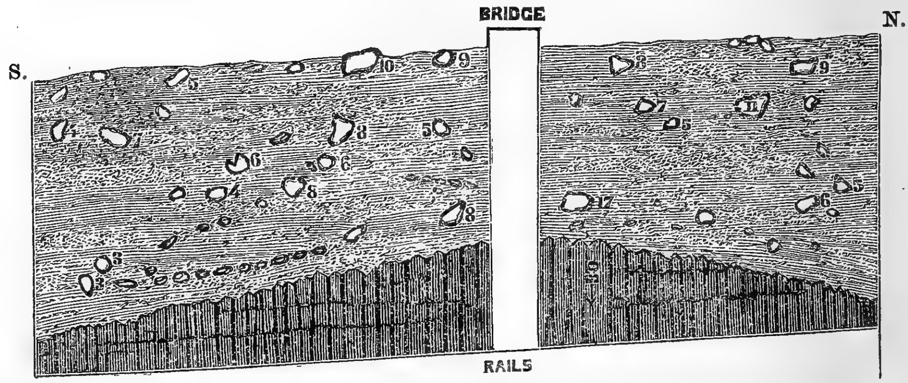
I wish to call attention to the position of this well-rolled loose gravel, containing many pieces of Old Red Sandstone and Millstone-grit, brought from above Merthyr and deposited at a very high level in the small valley cut out of the sandstone rock at Quaker's Yard. The rails are 393 feet above the datum-line at Cardiff, and the gravel is about 460 feet above the datum-line, and 163 feet above the river Taff, close by. If the horseshoe bend (Plate V.) had been gorged with ice at the gravel-period so as to prevent the passage of the river round the valley B H C, Plate V., then the river might have risen to a height which would have enabled it to pass along the line B D E F C; and the rolled gravel, which is a loose superficial deposit, may have been left by the last great flood.

Returning to Plate IV. fig. 1—before reaching E the rails cross a small lateral valley on an embankment 20 feet high, the surface of the ground dipping at right angles to the rails at an angle of 15°, and so reaching the river at an angle of 30°. The great gravel-cutting E F is now entered, and shows a maximum thickness of gravel of 70 feet.

The great cutting, E F, nearly in the line of the old incline, commences with a series of large blocks of sandstone from 6 to 9 feet long, laid at an angle of 1° N., and forming the last or topmost layer of the gravel. These great pieces of rock have evidently only descended a few yards from the mass from which they were detached. The gravel becomes 55 feet thick at a point (E) where the sand-rock is exposed (see fig. 6, p. 70). The sand-rock in the cutting is visible for nearly 60 yards to a height of 7 feet above the rails at the maximum. This gravel may be observed to be roughly parallel to the top surface of rock, which slopes gently to the south. The greatest thickness of gravel with large boulders occurs near F, reaching 70 feet. The slope of the surface is given at different points.

The larger blocks are often arranged in lines or planes of deposition, forming a distinct measurable angle. In the larger gravel-cutting, E F, they are not in any case more than 15°; near the viaduct they reach an angle of 35° near the rock. These planes follow, and are nearly parallel with, the surface of the rock which crops out at E, and are so arranged that the last bed of gravel forming the surface, being also the last superficial deposit, is also almost parallel with the top surface of the bed of stones on which it lies, just as the last bed is almost parallel with the mean angle of the surface of the rock on which it is spread by the action of water (see E). This section is to natural scale.

Fig. 6*.—*Section along cutting of Taff-Valley Railway.*



The exposure of rock at many different points of the horseshoe bend near the piers of the viaduct, and in the bed of the river, adds to the interest of the sections at Quaker's Yard. I shall now describe the character of this large rock-basin in which the gravel under consideration is contained. The first place at which I observed the rock was near the river, where a small quarry is worked close to one of the piers of the viaduct. The dip is slightly south-east, and the stone is divided by nearly vertical joints; there is another quarry of the same character on the opposite bank, between the tramway-bridge and the south-east end of the railway-viaduct, but close to the latter. In following the tramway round the horseshoe bend the rock is frequently visible; in the river-bed it is concealed by a coating of gravel as far as the junction of the stream at the north-east point of the bend. The gradient of this small stream is steep, and the water enters the river with some velocity, running nearly parallel with the Taff near the junction. The water of the Taff, up to the junction, is smooth, and flows quietly over a gravel bottom; but the lateral stream, coming in with added velocity, causes the stream of the Taff River almost to split into two different paths, one taking the east, and the other, or larger portion, crossing the bed of the river, and hollowing out a deep channel in the rock close to the west bank. The river flows below the junction at H entirely over rock, the gravel not being able to rest on account of the velocity of the current.

The action on the river-bed corresponds with what I have represented in other sections that I have made, which show that the work of denudation, or cutting out of the solid rock, is principally due to running water, either in the lateral streams themselves, or in the main river immediately after the side-stream has emptied itself into it. Of this I shall bring forward other examples at another

* Fig. 6 is also reversed. See Plate IV. fig. 1 at E.

time, to show that the work of denudation performed by the main stream flowing at the bottom of a deep valley becomes insignificant compared with that of the side-streams flowing into the main river. The river itself only operates on a narrow slip of ground at the bottom of the valley, although, by the momentum it possesses and its constant action, it has a powerful denuding force. The side-streams flowing into the river, on the contrary, although more intermittent, act on the whole of the remaining surface of the valley, either through themselves or their smaller tributaries. They thus denude an area twenty times as great (or even more) as the river itself can touch. The side-streams are less fixed in position, and run with many times the speed of the river itself. Their power as an agent of denudation is not in proportion to the average amount of water which they contain, but to their speed in flood-times.

The side-streams occupy channels of infinitely greater length than that of the main river. The points where the greatest force of water is employed now at the bottom of the Taff valley are where the water in the side-streams and the main stream unite, as at the north-east corner of the horseshoe bend at Quaker's Yard at H.

At the south-eastern corner is a large quarry close to the road, in which 60 feet of massive-bedded sandstone is seen. It is also seen in the river-bed.

As the rails near the viaduct are 96 feet above the level of the river, and as rock is seen 120 feet above the rails, and 96 feet below them, we have at least 216 feet of solid sand-rock exposed in these sections, without any intermixture of clay or shale. This is an important fact, as we may observe that a horseshoe bend of as perfect a form as in alluvial soil may be excavated in solid rock. Mr. Fergusson has attempted to prove that the sizes of the bends and curves in rivers depend upon the velocity of the river, and that a curve in a river falling 10 feet in a mile will be smaller than one in a river falling 5 feet in a mile; but at Quaker's Yard we have a well-formed large horseshoe bend in a river falling 50 feet in a mile. The laws which regulate the flow of rivers may be different in sand-rocks from what they are in alluvial soil; but I still hold the view as to the cause of these curves which I mentioned to the Society in 1852, but which it is unnecessary to discuss at the present moment *.

At A, Plate IV. fig. 1, the gravels are exhibited very clearly in the cuttings at and near Quaker's-Yard Station; these are 200 yards long and 40 feet deep, and are represented at the north end of the section. The local sand-rock furnishes the largest, most numerous, and least-rolled pieces, many of them 8 and 9 feet long. The boulders of Millstone-grit are generally well rolled, and not more than 6 feet long; those of Old Red Sandstone are throughout well rolled, and not often more than 2 feet. Not more than one stone out of 500 is derived from the Old Red Sandstone or Millstone-grit.

The gravel is supposed to be from 30 to 40 feet thick at A, covering the side of the hill to a height of 200 feet or more above the river.

* See Phil. Mag. 4th series, vol. v. p. 275, 1852.

The stratification is generally flat where the sand is bedded at all; but the junction of the sand-rock and gravel is rarely seen at any part of this section north of the viaduct.

The gravel of the Taff retains its character as far as the sea-coast, and resembles that of the Neath river, described by Mr. Moggridge, Quart. Journ. Geol. Soc. vol. xii. p. 169. During the excavations for the Swansea Docks, Mr. Moggridge found part of this river-gravel, which he identified by the presence of river-rolled Old-Red-Sandstone, Limestone, and Millstone-grit boulders (which had come from the parent-rocks, more than twenty miles distant) above stratified beds of marine clay alternating with peat. The marine clay contained *Scrobicularia piperata,* a shell which now lives abundantly in the sands of the adjoining shore.

The river Taff and the Swansea and Neath rivers expose sections of gravel all along their course to the sea-coast; and the ancient banks and river-beds of these rivers consist of well-rolled boulders from the higher districts, deposited with those of local rocks in every part. Their ancient banks have a contour and escarpments like those of the Aire (see Plate IV. figs. 4 & 5). The gravel becomes rather smaller as the sea-coast is reached, and has then, no doubt, been removed and redeposited many times. The gravel near the level of each river is of similar age throughout its course, and must be considered very recent.

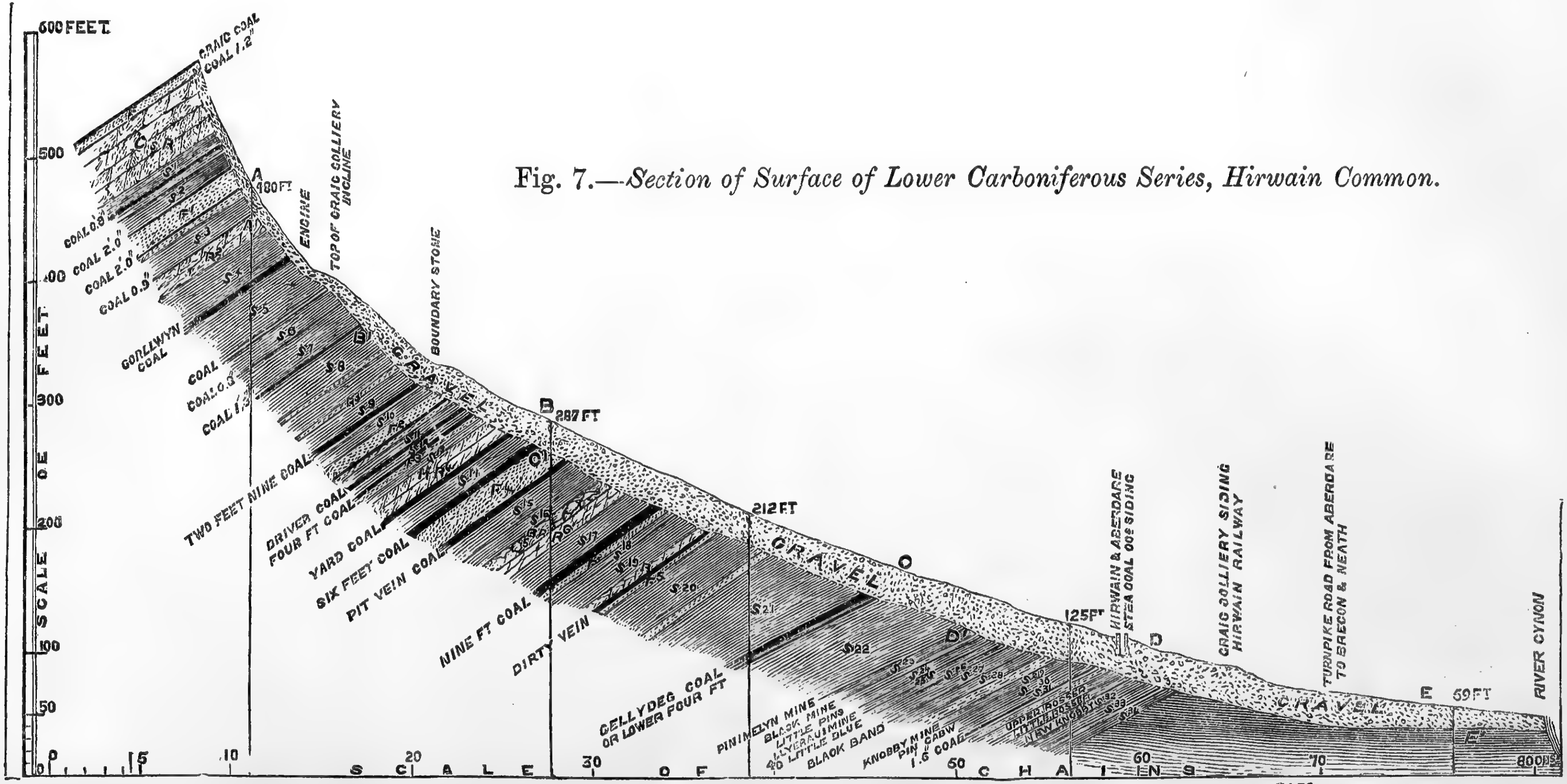
Mr. Godwin-Austen (Quart. Journ. Geol. Soc. vol. vii. p. 134, pl. 7) also describes this part of South Wales under the heading "Insulated Areas in periods of greatest depression," from evidence of a very different character from that offered by me.

Fig. 7 is accompanied by a scale of heights in feet, and of length in chains (66 feet each), and is a reduction by the pentagraph of a section taken for me in 1867 to determine exactly the thickness and position of the Hirwain gravel. (See Map, fig. 3, page 67.) The thick deposits of gravel on Hirwain Common are cut through by several rapid streams flowing from the lofty range of hills separating Hirwain Common from the Rhondda Valley. I have selected the section, fig. 7, along the course of one of the Hirwain streams, as an instance of the continuity of gravel from high ground to the bottom of the valley, and of the regularity of the action of denudation and also of deposition.

Fig. 8 is a reduction from a drawing made of an excavation in the gravel and the underlying coal-seam. The gravel is tinted to represent the lower, middle, and upper gravels. The lowest portion consists principally of the clays and shales of the Lower Coal-measures, slightly moved from their outcrop down towards the river Cynon. The middle division is stronger clay than the upper; but as the gravels approach the river they become sandy, and have been worked over for the limestone boulders they contain, and for sand for the use of the furnaces at the ironworks.

This sketch gives an actual view of the passage of the soft beds of the Coal-measures into gravel, at the end of the gravel-period. This excavation gives a better illustration of the actual process of denu-

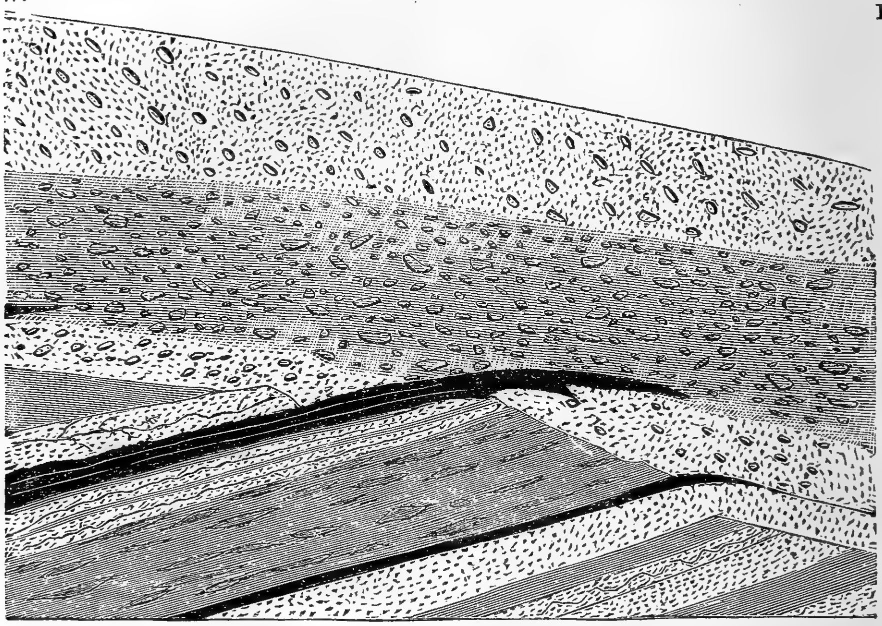
Fig. 7.—*Section of Surface of Lower Carboniferous Series, Hirwain Common.*



The author is desirous of drawing the attention of geologists to the contour of the surface in this section, as illustrative of his hypothesis of parabolic curves, enunciated in his paper read on November 11, 1868 (*suprà*, p. 7).—Edit. Jan. 28, 1869.

dation than can be obtained from natural sections in brooks, where the different gravels are moved and mixed up together by the recent action of water. The total thickness of the gravel is 18 feet.

Fig. 8.—*Section showing Coal-seams squeezed into drift during the deposition of the lowest gravel on Hirwain Common.—Natural scale.*



Bacon Hole, Gower, S. Wales.

Near this well-known cave limestone-gravel lies on a very steep cliff of limestone, in some places sloping as much as 70° to the sea. The top surface of this gravel lies at an angle of 34°; and the bottom fills up the concavity in the limestone rocks. The path to the cave passes over this gravel, which is entirely composed of sharp angular fragments of limestone, cemented together by carbonate of lime, a process which seems to have been common in the Quaternary period. I noted, on a previous occasion, the manner in which limestone-blocks had been observed by Mr. Pengelly to be cemented together near Torquay, at a considerable height above the sea.

The mass of limestone-gravel falling down this cliff, accumulating in concavities, and sloping to the sea at an angle of 32° S. on the surface, may be seen at a height of 120 feet above the sea. In its course from the high cliffs above, it seems to have sent off a vein of gravel at a point 70 feet above the sea, to the east, at an angle of 11°.

This vein of angular gravel thickens to the east, and expands to a thickness of 25 feet when it reaches the opening in the limestone cliff called Bacon Hole, a deep fissure penetrating a long distance into the limestone cliff, in a northerly direction, and having a roof with an acute angle, which has often been described.

The gravel here includes some enormous blocks of limestone, which have fallen into it from the rock above. When this stream of gravel reaches the mouth of Bacon Hole, it turns sharp round into the cave in a northerly direction, the angle of deposition changing to 25° N., the floor of the cave being about 30 feet above high water. The limestone-gravel is covered with the black bone-earth in which so many remains of Elephant and Rhinoceros have been found in the cave, and is mixed with marine shells of species now living on the coast and in the sea-sand. The whole is covered with stalagmite, from 2 to 3 feet thick, also sloping northwards at an angle of 25° N. There are layers of stalagmite included within the limestone-breccia (proving changes in the conditions of deposition at intervals) in the cave; but the gravel, although so much higher on the side of the cliff to the west, does not fill up the whole of the cave.

Looking at Dr. Buckland's drawings of caves, I think there is evidence that much of the loose materials which have formed the cave-deposit have passed downwards from the subaerial gravels on higher levels, and continued through and over the caves as far as the level of the sea, lake, or river below them.

All English bone-caves are at levels within 150 feet of running water at the present time, or of the sea; and the great majority are within the limit of 70 or 80 feet, their fossiliferous contents corresponding in level with all the known fossiliferous gravels containing mammalian remains, including the Crag.

In the period referred to, water ran apparently in the bottom of the valleys which are now dry.

All bone-caves seem, at the time of the deposition of their contents, to have been in situations where water traversed them from fissures above, and flowed into them from the side streams flowing along the valleys in which they are situated, and they offer evidence of an immense rainfall at the period of the deposition of the cave-gravels. The very washed condition of the materials found in bone-caves, and the manner of accumulation, indicate that their contents were more derived from above than below; and the enormous pieces of limestone which have fallen into the gravel at Kent's Hole and Bacon Hole show that there must have been not only the action of running water thereon, but the force of a column of water upon the cave to dislodge the pieces from the roof.

There are in all caves apertures in the roof, evidently worn by water coming through it. I observed a good instance of this in the Paviland Cave at Gower (close as it is to the sea), and another in Brixham Cave. Some years since, I believe, it was remarked by Dr. Buckland that there were always at least three openings in bone-caves, two of them from higher levels than the mouth.

The subaerial gravel comes down the steep slopes of the limestone cliffs at Gower from a great height, and falls into a stratified marine deposit, just as it falls down the steep cliffs into the Hopes-Nose raised beach, near Torquay, where it is mingled with the sea-sand, pebbles, and shells deposited almost horizontally on the limestone rock.

Transverse Section of Rhondda Valley.

The Rhondda river unites with the Taff river twelve miles below Quaker's Yard, and fifteen miles from its source.

The transverse section across C measures 1730 yards from the opening of the levels on the opposite sides, 84 yards on the west side, and 79 yards on the east side, above the level of the Rhondda river, at the point C.

The gradient from the west level (D) to the river is 1 in 13, that from the east level (C) is still steeper, being 1 in $8\frac{1}{2}$; so that the sides of the valley slope at 1 in 11 on the average (from C and D to the river), or at an angle of 8°. The point C is about four miles from the furthest watershed of the river beyond.

Below the level of the quarry, on the west side, above the river, there is no rock seen except at one point in a watercourse.

The dip of the Coal-measures at this point (D E) is about 3° north, and the section (Pl. IV. fig. 3, D E) is nearly east and west.

The escarpment of the high ground above D and E is nearly twice as steep and high as that of the South Downs, and pursues its course nearly north and south along each side of the Rhondda valley. The dip varies, sometimes being northerly, and at other times south. This is marked by the arrows in the Ordnance map; and the lines of outcrop of the coal also show the direction of the escarpment. The escarpment, therefore, in the Rhondda valley is in the direction of the dip, and not of the strike; and the dip changes without any alteration in the direction of the escarpment. In fact, in this district, we have in a short distance escarpments parallel with the dip and strike, and also at almost every angle to them.

The valley is at D E about 300 yards deep, but is not shown above the quarry in the diagram, as I do not allude at the present time to anything more than the portion of the gravel in the valley below the No. 2 vein of coal. I visited this pit several times during the progress of the sinking, and counted the proportion of rolled to weathered stones each time. About one-eighth of the gravel in this pit was well rolled, the remainder being generally weathered.

It is evident that if only one-eighth of the gravel is rolled by the river, seven-eighths of it must have been obtained from the sides of the valley, west and east of the pit, and only one-eighth from the north, and that the valley was then widening much faster than it was lengthening in the latter part of the Quaternary period. There are times in the denudation of valleys when pluvial action on the sides of the valley is much greater than fluvial action in the centre of the valley. I mentioned (Quart. Journ. Geol. Soc. vol. xxiv. p. 117) that even in the valley of the Somme, where the fall of the river is so small, a great mass of the material deposited in the concavities of the valley near the margin of the river is derived from the adjacent country, and has never been river-borne. Different as is the position of the gravel of the Rhondda, in this respect it resembles that of the Somme.

The gravel-deposit continues for the whole length of, and is also met with at a considerable height above the Rhondda river. The cause of this great fall of rock and clay is due to the position of the permeable and impermeable beds, and the influence of the immense rainfall occurring, I believe, at former periods, which has detached large portions from the high ground on the side of the valley, and let it fall into the channel of the river below.

The character of the deposit in this valley is very simple; it is sand-rock, clay, and shale, derived from the adjoining higher beds. In the pit sunk near C all the stones were either weathered or rolled, including one block of several tons weight. As the Rhondda valley is separated by a hill 800 feet high in one part, and 600 feet from Hirwain in the lowest part, above the river-course, which flows off from the Millstone-grit and Old Red Sandstone, there are no boulders of these rocks in this valley; all is purely local.

In sinking the pit at C, which was 20 feet in diameter, the rock was reached on the west side of the pit 8 yards before solid ground on the east side was met with, so that the angle of the escarpment of the ancient bank of the river or side of the valley was about 50° to the ancient river.

By means of this sinking it is known that the gravel there is 101 feet thick; and, taking the average thickness to be 20 yards, and the width 1700 yards, there would be 34,000 cubic yards in each yard run (supposing that section C represents the average amount of gravel in the valley), which, at $1\frac{1}{2}$ ton to the cubic yard, represents 89,760,000 tons of gravel to the mile. The river flows over at least 50 feet of gravel, and probably much more.

The section of gravel passed through in the pit is as follows:—

	ft.	in.
Turf or peat	3	6
Blue clay with large stones	23	6
Sand	18	0
Blue clay	5	6
Gravel with large stones	26	6
Gravel with clay	13	0
Cliff	5	0
Gravel	6	0
	101	0

The fall of the Rhondda river in the distance of a mile before it reaches C is about 500 feet, in which distance there are two waterfalls.

The vast extent and the character of the Rhondda gravels proves that the denudation of the Rhondda valley was not dependent upon large rivers, or marine or glacial action, but might have been caused by intense pluvial action.

In a wet season, water pours over the escarpment along the edge of the hills into the Rhondda valley, and is not confined to a few distant watercourses; but there is no evidence of any accumulations of gravel now; perhaps the fall of stones along the escarpment equals the quantity carried down the river in floods.

The Salisbury pits are celebrated for their mammalian remains, which, according to Dr. Blackmore, are associated with flint instruments of the Amiens type.

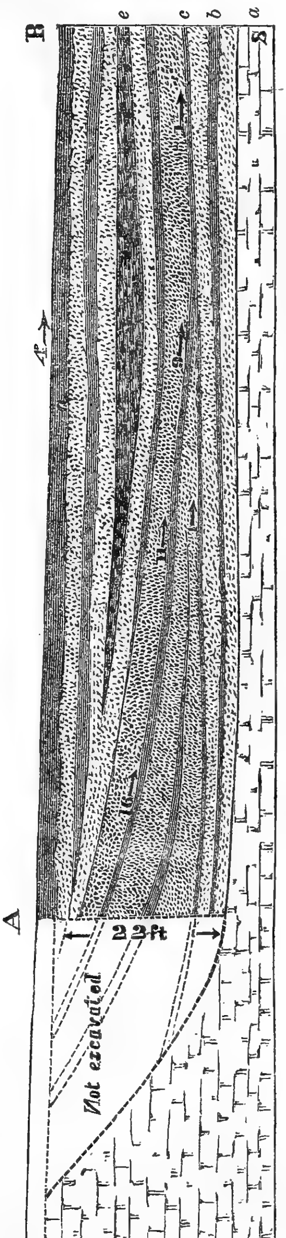


Fig. 9.—*Section near Salisbury.*

Land and freshwater shells are very abundant. The great shell-bed is near the chalk, lying upon a bed of gravel; and the Pupa-bed touches the lower surface of the covering bed of gravel, *e*. While the curve of the surface is on the average 3° between A and B, the dip of the lower gravel, *b*, where it touches the escarpment of the chalk, will probably lie at a very steep angle.

The Pupa-bed, *c*, a fine loess, is marked by a distinct band of colour; it is about 2 ft. thick, and slopes to the river in a gentle curve. I have marked its dip 16°, then 11°, then 9°. The bed *c* contains only six species of shells, *Helix arbustorum* (?), *Helix hispida, Zua lubrica, Lymnæa palustris, Valvata piscinalis, Pisidium obtusale*, besides the *Pupæ* in immense abundance. The lower band *b* contains thirty-one species of terrestrial and fluviatile shells, according to the lists of the late Mr. John Brown and Dr. Blackmore.

The chalk, *a*, is 30 feet from the surface at A, but in 30 yards it reaches the surface; so that the escarpment in the part not yet opened is known to be at an angle of 30°, sloping towards the river. As is usual, the brick-earth is thickest a little way from the escarpment, and passes, on the same horizon, into gravel and sand as you approach the river.

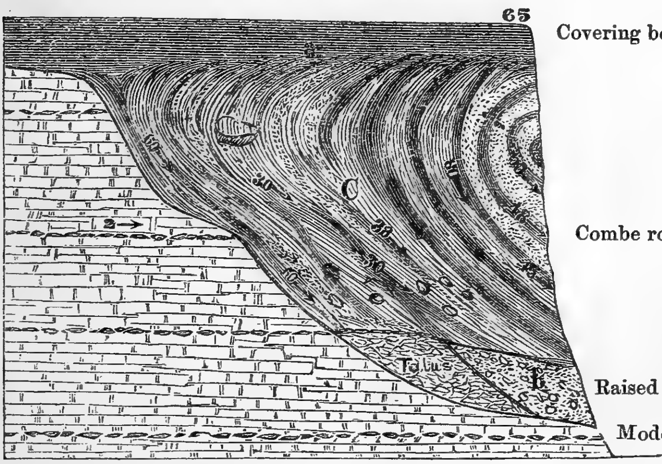
The remains of another arctic mammal (the Musk-Ox) have been recently found in the loess at Salisbury. This animal is now living in a remote part of North America. The stratification at Salisbury, shown in fig. 9, is very similar to that at Erith, fig. 17.

The mammalian gravel and Combe rock extends from Brighton, without interruption, to the point drawn, fig. 10, and presents a cliff of roughly stratified beds facing the sea, about 60 ft. in height.

The escarpment of the chalk is known to be not far distant in the rear of the present face of the cliffs at any point; and an extensive fall of gravel has exposed the escarpment of chalk. In the steepest part it is 60°, S., curving gradually towards high-water mark. At *b* the raised beach of flint-shingle, with masses of slightly rolled chalk, is seen reposing on it, dipping to the sea at about 6°, and above 8 or 10 ft. above the present high-water mark.

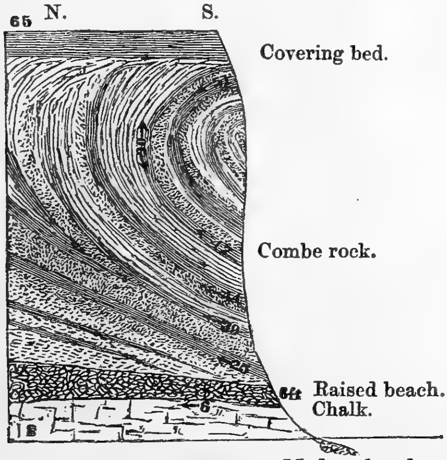
There are alternations of beds of very large flints beach-rolled, and layers of chalk débris, many pieces with the corners slightly rounded, varying from 6 in. to 2 feet in length. The fall of cliff at the spot represented in fig. 10 enables the geologist to measure the

Fig. 10.—*Section about half a mile East of Sussex Square, Brighton.*



angle of deposition of the gravel and Combe rock north and south, and also to observe the face east and west. The dips at several points have been marked in the sketch. The raised beach dips south at from

Fig. 11.—*Section at Brighton.*

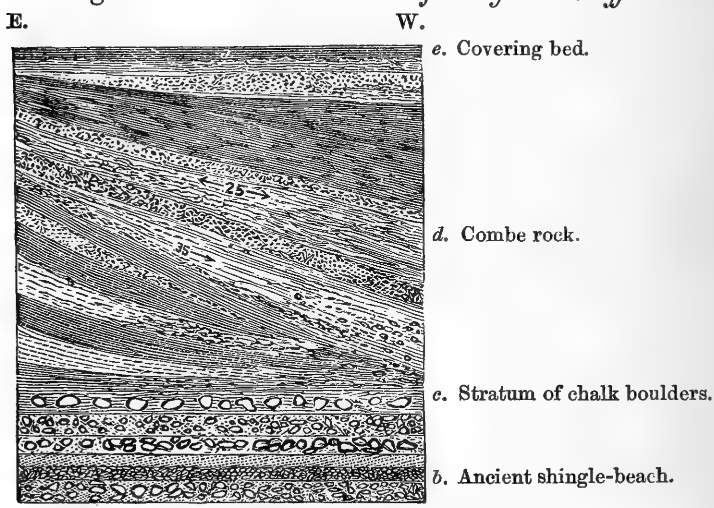


6° to 8°, and the covering bed also south at 2°. We thus meet near the sea with the condition of the basement bed of gravel (*b*, fig. 10) and of the covering bed of gravel being deposited nearly horizontally, while the intermediate series of stratified gravels, with the lower beds called Combe rock, a mixture of chalk and flint with yellow clay, have been pitched and washed by pluvial action over the escarpment. These materials, derived from the high ground behind the escarpment, and thrown over it, have not been sufficiently water-washed, nor perhaps even placed within the reach of water flowing sufficiently fast, to remove the angles of the soft chalk fragments; nor has the act of deposition abraded the edges of the flint, which are often splintered before being bedded in the Combe rock.

Fig. 11 is another view of the structure of the Brighton gravel-bed, at a point a little to the west of fig. 10, where the escarpment of the chalk must be very near the face of the cliff. The raised shingle-beach is 6 ft. thick, and falls at 8° south to the sea. The position of the present beach is shown 9 ft. below the ancient one. Dr. Mantell first obtained remains of *Elephas*, from these deposits, near Sussex Square; but no shells have yet been found in them.

Fig. 12 has been, by mistake, reversed in the drawing, and is

Fig. 12.—*Vertical Section of Brighton Cliff.*



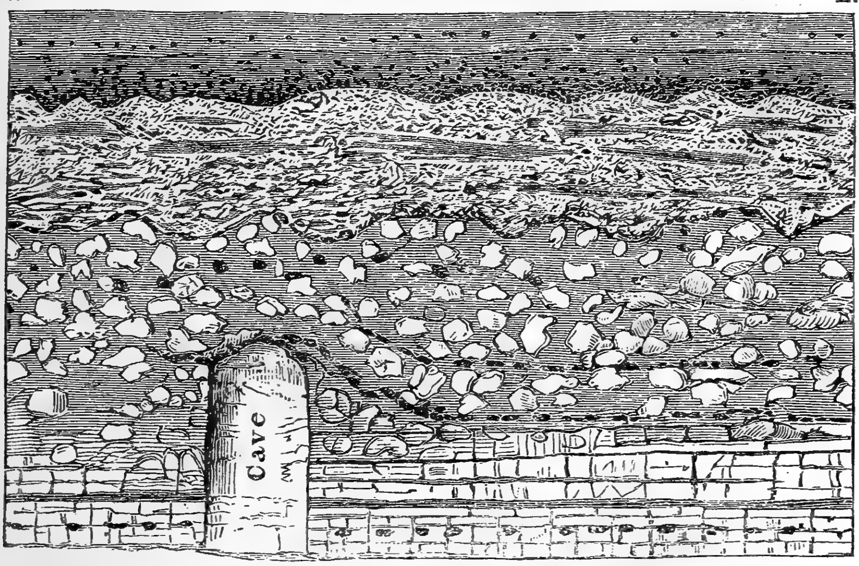
a vertical section of the Brighton gravel-beds at a point intermediate between that shown in fig. 10 and Sussex Square. By means of a footpath up the cliff, I was enabled to determine the dip of part of the middle series of gravels (*d*) to be 25° west. The covering bed and gravel (*e*) and the raised beach deposited at the bottom (*b*) appear quite horizontal at that point.

The old beach (*b*) is about 7 ft. thick, and the chalk boulder-bands (*c*) interstratified with flints about 9 ft. thick, the cliff being about 63 ft. high.

Fig. 13, on a larger scale, exhibits a front view of the cliff 100 yards east of the Rottingdean landing-place, three miles east of Sussex Square, Brighton. This is near the termination of the Brighton gravel-deposit; and I have drawn it to show the manner in which the gravel reposes in a hollow of the chalk, formed by a stream which reached the sea at Rottingdean in the gravel-period.

There is a bed of marl on the 6 feet of solid chalk, shown in fig. 13,

Fig. 13.—*Section of the Cliff East of the Gap, Rottingdean, Sussex.*



and also continuous bands of flints. We can thus accurately observe the marks of the movement which has taken place in the upper surface of the denuded chalk. The bed of tabular flints, about 1 inch thick, touching the upper part of the artificial opening marked *cave*, is fractured and contorted, while the traces of a still higher band of large detached flints are visible in the gravel above the top of the cave, where it ends. Then comes a coarse ochreous flint-gravel 7 feet thick, with veins of sands and some chalk fragments. This is eaten into by the covering dark bed of sand with flints. The middle portion of this section is chalky, and must have been more altered by chemical than by mechanical action, as the flint-veins have been so little disturbed. At p. 113 of the last volume of this journal I gave some illustrations of the destruction of chalk *in situ* by some kind of chemical action, which was probably contemporaneous, if not identical, with that which has eroded the surface of the chalk, and formed pipes over such large areas.

Fig. 14, representing the highly-inclined chalk with flint veins 200 yards east of Freshwater Gate, Isle of Wight, is given for comparison. The covering bed is nearly horizontal, as usual. The character of the chalk and the disposition of the gravel closely resemble those at Rottingdean; and the latter is about the same height, from 25 to 30 feet. Mammalian remains have been found in this bed close by Freshwater Gate.

Fig. 15, Sangatte Cliff, near Calais, is given for comparison with these Brighton sections. The escarpment of the chalk, near the upper part is 43°, then it reaches 55°, and descends to 43°. The Sangatte raised beach is just above the level of high water at this point, and is composed of large flints and pieces of chalk, as at Brighton.

In the middle of the Sangatte series a line of chalk boulders, deposited at an angle of 12°, is shown in some places. At about half a

Fig. 14.—*Section of Cliff East of Freshwater Gate, Isle of Wight.*

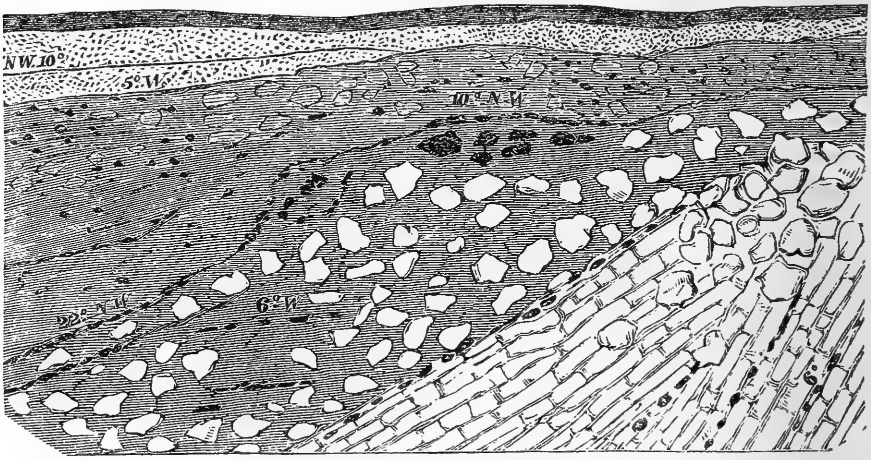
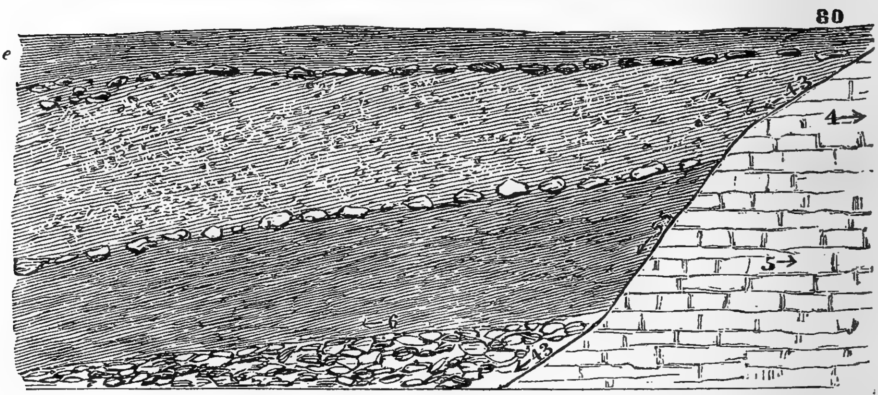


Fig. 15.—*Section of Sangatte Cliff from the beach.*



mile from this point Mr. Prestwich found, just above high-water mark, abundance of freshwater shells of living species in a fine tranquilly deposited marl covered by 50 feet of gravel, continuous with the upper 30 ft. of the gravel shown in fig. 15. The slope of the covering bed of gravel (*e*) is not more than 1° or 2°. There is very high ground at the back of this section (which is near Cape Blanc-nez), from which the chalk and gravel were derived and thrown over the ancient chalk-cliff 80 feet high.

Near the village of Sangatte the covering gravel reaches high-water mark, and the whole of the middle series intercalated between the basement gravel and the covering gravel is seen.

While the materials of the gravel at Sangatte are principally brought over the cliff from the high land, they are interstratified with an ordinary beach and with a lacustrine deposit formed at the same time within a few feet of the present level of high water.

A similar beach, or a similar lacustrine deposit, might be formed at the present time; but the physical conditions under which a gravel-deposit like that at Sangatte could occur do not exist at the present time in France. It would require the rainfall of a pluvial period to furnish the fresh water to lay down such a thickness of gravel as that of Sangatte in such a position on the sea-coast.

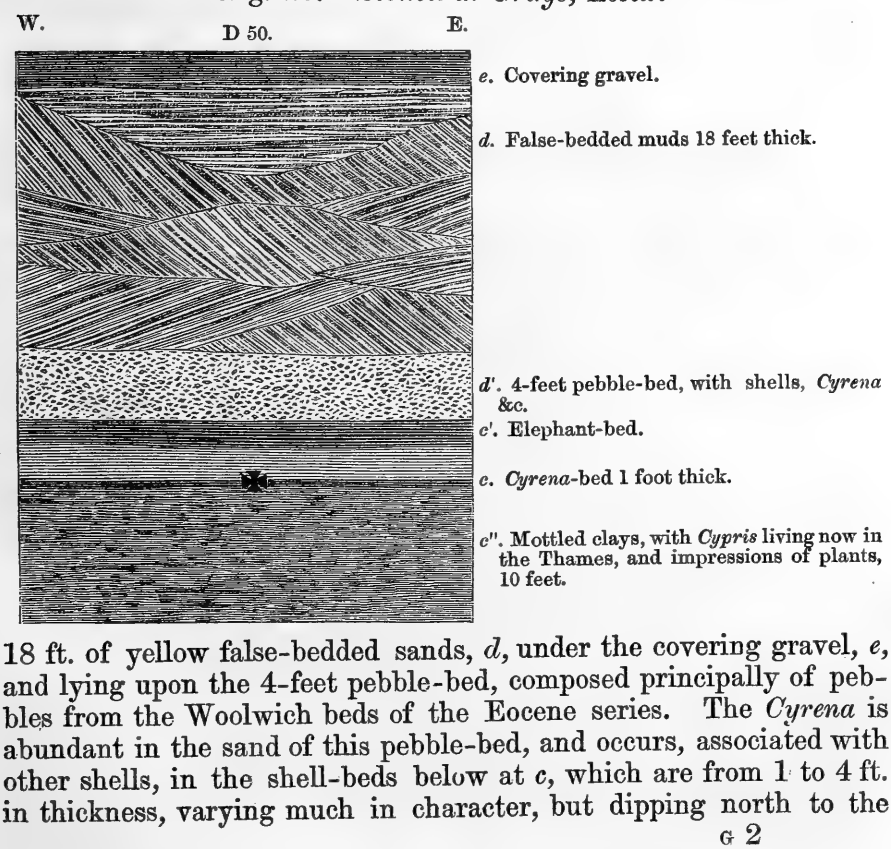
Thames-Valley Gravels.

The section from the surface of the Thanet Sands, 86 feet above the Ordnance datum-line, to the river Thames, through the celebrated Cyrena-pits (Pl. IV. fig. 6), is drawn to an exaggerated scale of heights, in proportion to lengths, through the points A E I, approximately laid down on the map, Pl. IX. Pl. VII. is a copy of part of the Ordnance Parish Map of Grays reduced to half size.

An excavation into the chalk between B and C offers an opportunity of observing the Thanet Sands quite undisturbed at a distance from the surface of 27 ft. at C, and of 35 ft. at B; the dip of the chalk is there slightly south, the thin covering of gravel *e* dipping south. There is no opportunity of examining the structure of the ground between C and D, as it is not excavated; but I expect the section resembles that at Crayford, on the opposite side of the river.

Fig. 16 is a transverse section near the point D, showing about

Fig. 16.—*Section at Grays, Essex.*



18 ft. of yellow false-bedded sands, *d*, under the covering gravel, *e*, and lying upon the 4-feet pebble-bed, composed principally of pebbles from the Woolwich beds of the Eocene series. The *Cyrena* is abundant in the sand of this pebble-bed, and occurs, associated with other shells, in the shell-beds below at *c*, which are from 1 to 4 ft. in thickness, varying much in character, but dipping north to the

escarpment C. The beds below *c* are stratified clays, sometimes mottled, and are said to repose on the lower gravel. This lower gravel is said to be 3 ft. thick; and at 45 ft. from the surface the chalk is said to be found near D; but I have not seen this myself.

Some years since, an excavation was made near M, and chalk was found about 43 ft. from the surface. The false-bedded sands were 20 ft. thick at that point, and covered the upper-gravel series, *e*, very full of flints and pebbles*.

The Mammalian remains occurring in the gravel, *f*, are more rolled than those found in the brick-earth above.

A list of Grays species has been published by Prof. Morris, and also in the Geological Society's Journal, vol. xxii. p. 101, by Mr. Boyd Dawkins.

Returning to Pl. IV. fig. 6, the false-bedded sands are represented thinning out towards the river, as well as the Cyrena-beds. The depth of the chalk below the surface is ascertained by a well-section at F; and the covering gravel, *e*, comes in contact with the lower gravel, *f*, near the railway-cutting, *g*. Close to this point there was a section of coarse gravel, 12 ft. thick, open in a gravel-pit, reposing upon chalk without any beds of sand or brick-earth. The chalk is said to have been seen in the railway-cutting 9 ft. above the rails at the bridge I. In the tramway east of, and close to, Grays Station, the chalk is also well exposed 6 feet above the rails, with thick beds of gravel lying irregularly upon it, and some brick-earth beds and gravel above them containing comminuted shells derived from the Woolwich series, which beds have been entirely removed by denudation at Grays. In excavating for a cellar near Grays church, a very large mass of sandstone was found about 20 ft. above the Ordnance datum-line, many tons in weight, in the gravel close to the chalk. Such stones are abundant in the upper gravel in the Chalk and Thanet Sand west of the Grays Station.

Great changes have taken place at Grays, by removal of brick-earth, since Professor Morris first described the fossils from the Thames-valley deposits; and he is almost the only geologist who has watched the excavation from year to year. It will be seen from Pl. IV. fig. 6, that, like the gravels of the Somme, the fossiliferous brick-earths of Grays are deposited in a concavity of the chalk. The chalk is 15 ft. lower at D than at G, and 43 ft. lower at D than B. The old Thames river seems to have divided into two channels at Grays; and the fluviatile deposits between C and G appear to have occupied one channel, thus forming the whole series of stratified beds which are intercalated between the gravels *e* and *f*.

The last deposit was the covering gravel-bed, *e*, which is continuous from the marsh to the point A, and beyond it.

The position of the section (Pl. IV. fig. 7, Erith) A B S T is laid down on the sketch map, Plate IX.; and A B, the part near the escarpment of the Chalk and Thanet Sands, is enlarged in fig. 17. page 85. Although Erith and Grays are not exactly opposite each other on the Thames valley, yet the sections, Plate IV. figs. 6 and 7,

* I obtained this information from Professor J. Morris, F.G.S.

will give an idea of the surface-configuration of the Thames valley and of the position of the fossiliferous gravels. The top bed of the Chalk and the basement bed of the Thanet Sands are well seen at G, Plate VIII. (fig. 18, p. 86), at a height of 46 feet, at Erith; and at B, Plate IV. fig. 6, Grays, at a height of about 47 feet above the Ordnance datum-line.

This basement bed is 70 feet at Purfleet, and 66 feet at Crayford (fig. 22) above the Ordnance datum-line.

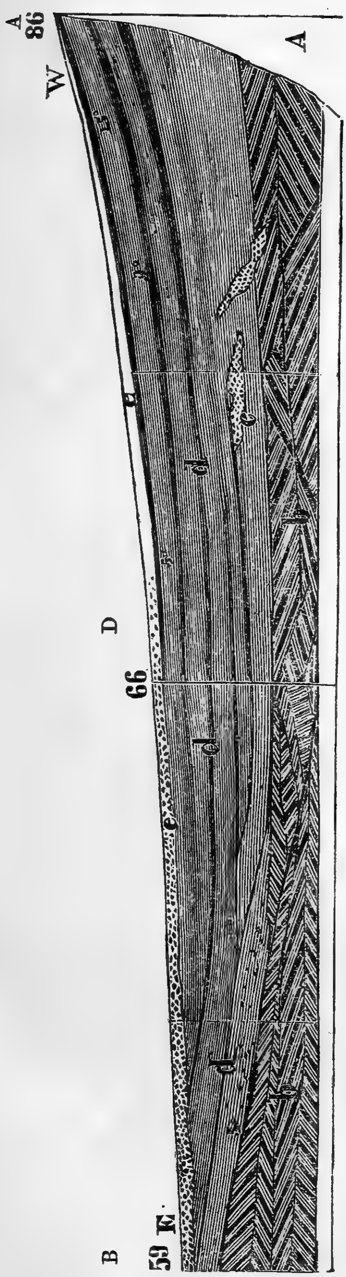


Fig. 17.—*Section of the Cyrena-pit, Erith.*

The supposition of Mr. Searles Wood, jun., that the Thames valley is in a line of fault appears to me inadmissible, as far as Grays, Erith, and Crayford are concerned. The sections I now bring forward will show that the Thames valley has been excavated by river-action out of a mass of chalk and Thanet sands, lying nearly horizontally in the localities referred to. Beyond the districts referred to there is a flexure in the chalk which depresses the basement-bed of the Thanet sands from 46 feet at G, Plate VIII., Erith, to about 10 feet above the Ordnance datum-line at Erith station, without any fault. It is seen again at Woolwich and Lewisham, at the same height as at Erith, before it sinks under the London basin.

Referring to Plate IV. fig. 7. The chalk has been seen at A, 50 feet from the surface and 36 feet above the Ordnance datum-line, also in a well at S, 13 feet the above datum-line. It is said to be very near the surface at S, and that it is visible at low water for a mile between Erith and Crayford Ness, T. Although the ground along B S has not been excavated, like the other side of the Thames at Grays, it is known that the brick-earth thins out, and that the lower gravel (*f*), separated from the covering gravel (*e*) by brick-earth (*d*) and sands (*c*), together 50 feet thick between A and B, come together at S, just as *e* and *f* touch each other in fig. 6, Plate IV., as they approach the centre of the valley.

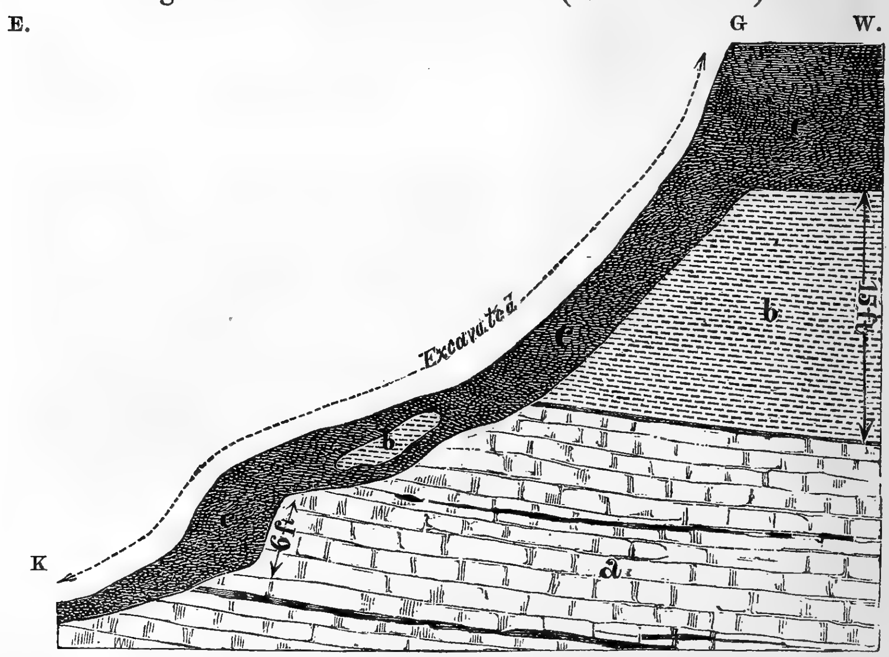
The escarpment of chalk and Thanet sands has not yet been excavated west of A; but I have no doubt that the fossiliferous gravels, A B, will be found to lie in a similar concavity to those at Grays and Crayford, where the Thanet sands and chalk have been exposed.

The material for the beds *e* and *d* seems to have descended from A, and to have been brought by land-floods, and contains bones, but no shells except derived ones. On the contrary, *b* is full of shells deposited quietly. Many of the species are extremely delicate, and are found quite as perfect as recent specimens; the two series of deposits are interstratified together at D, the eastern bed (*b*) being of fluviatile origin, and the western (*d*) being apparently of pluvial origin, and more due to land-floods.

The chalk below A in fig. 19, Erith, along the line A B, Plate VI., is 50 feet from the surface. The bottom-bed (*b*) shown in the section is false-bedded sand with a few veins of gravel. The *Cyrena* is very abundant between D and B in this sand (*b*). The mammalian remains are most abundant in the brick-earth beds (*d*).

These beds (*d*, *d*) dip near A at 25° E, then fall to 9°, 5°, and eventually dip 5° W. near B, forming a gentle curve. The covering bed (*e*) is 4 feet thick, and full of the Woolwich pebbles between B and D. It then changes its character, and contains only a few flints, but masses of the Woolwich shell-bed when it reaches A. The remains of this shell-bed occur through *b*, *c*, *d*, and *e*. The angles of deposition were observed both by Mr. S. Skertchly and myself in 1868, and the heights were measured by the former. Great removals of brick-earth have recently been made near A, so that the original section cannot be seen.

Fig. 18.—*Section in Erith Pit.* (Natural scale.)

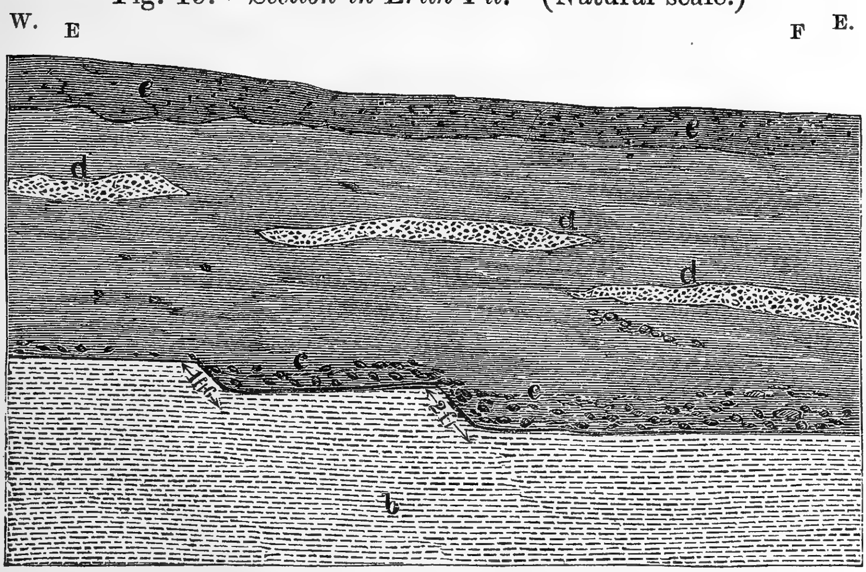


Between B and C, Plate VIII., a long face of the *Cyrena*-sand-bed is exposed at 45 feet above the Ordnance datum-line. I have found the *Cyrena* at about the same height at D; and this is the highest level at which the *Cyrena* is found either in the Thames valley or in the Humber or Somme.

Fig. 18 is a section exhibiting the excavation of the chalk and Thanet sands by the old River Thames. The chalk (*a*) reaches a height (fig. 18) of about 45 feet above the Ordnance datum-line; and the Thanet sands (*b*) have been partly denuded, so that only 15 feet, out of 60 feet seen in the Station ballast-pit at Erith, remain here. The gravel (*c*) reposes conformably on the top of the Thanet sands at G, the upper part of the section; but the gravel follows the denuded surface of the chalk, filling up the concavities. It contains much rearranged Thanet sand; and a large lump (*b*) is conspicuous in it. The 6-feet step in the chalk is well marked and sharply cut out by the action of the river flowing at right angles to the line G K.

Fig. 19 is a section in the same direction as fig. 18; but steps from

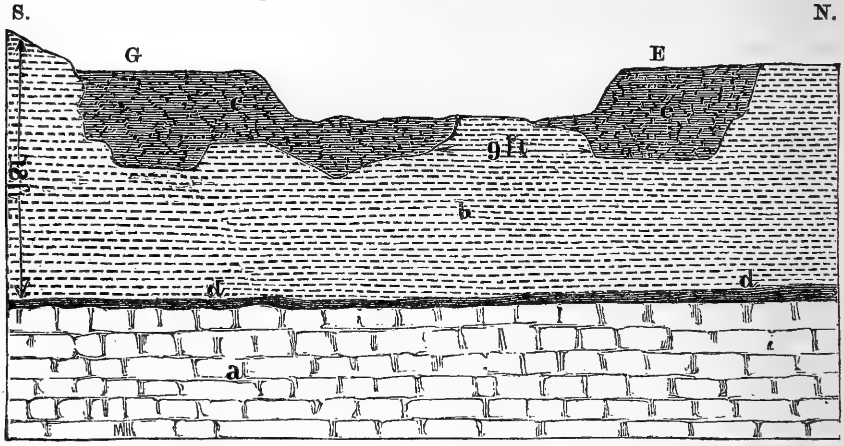
Fig. 19.—*Section in Erith Pit.* (Natural scale.)



1 to 2 feet deep, cut by water in the Thanet sands, are distinctly seen. The gravel is then deposited in the concavities formed by the water. Brick-earth, with veins of gravel (*d*), follows on for 15 feet, and the covering gravel (*e*) succeeds, sloping to the river at a gradient of 1 in 200 only. The Thanet sand is a somewhat incoherent mass; and the action of the water must have been very gentle to have formed such perfect steps. The deposition of gravel and brick-earth must have at once followed the denudation.

Fig. 20 is a section along part of the line G E. The chalk, with a basement-bed of Thanet sands and green-coated flints, is seen at *d*, *in situ*. The Thanet sands, in fig. 20, were excavated by one of the side-streams which formerly flowed into the ancient Thames. The edges of the sand (*b*) are so sharply cut in this transverse section of a river-bed that it would be difficult to believe it was not an artificial excavation, if other sections, such as fig. 19, did not exist close by. The gravel (*c*) fills up the inequalities in the sand.

Fig. 20.—*Section in Erith Pit.*

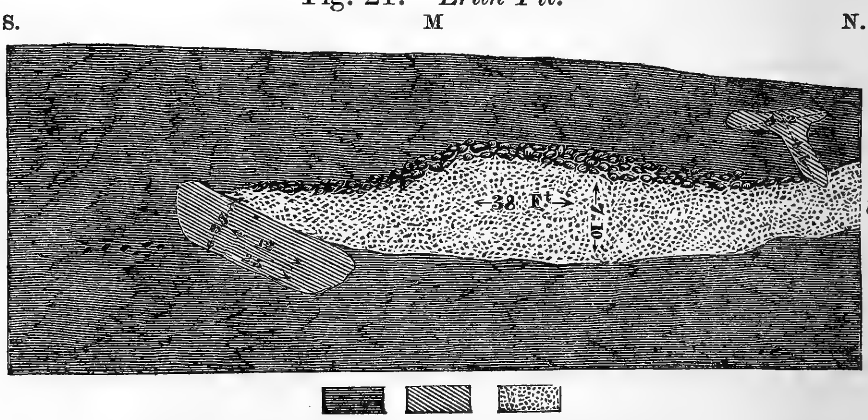


Rearranged Thanet sand is frequently met with in these gravels, which were formed out of materials derived from this bed during the excavation or deepening of the Thames valley and its tributaries at this period. The large bull's-head flints from the basement-bed are carried down to lower levels (owing to their weight) and deposited on the new surface of the chalk.

The pebbles from the Woolwich bed are most abundant in the middle part of the Thames Quaternary series, and have been carried a great distance from and below the escarpment before they were redeposited in the gravel.

Fig. 21 is from a drawing on wood by Mr. S. Skertchly of a mass

Fig. 21.—*Erith Pit.*



b. Thanet Sands. *c.* Woolwich shell-bed. *d.* Purple clay.

of Thanet sands (*b*) 38 feet in length by 7 feet 10 inches in width, with a portion of the Woolwich pebble-bed attached to it, lying upon and against one piece of the Woolwich shell-bed 12 feet by 6 feet

5 inches (*c*), and near another fallen piece,—the whole enveloped in a mass of purple clay (*d*), which may be either Plastic or London clay rearranged, and which often contains pieces of rolled chalk, like what is called Till or Boulder-clay. The situation is near M, Plate VIII., Erith; and the height of *b*, fig. 21, is about 65 feet above the Ordnance datum-line. Large pieces of the Woolwich shell-bed, with masses of purple clay, occur in the ordinary covering bed (*e*) near I, at a height of 55 feet. This covering-bed loses its pebbles at J, and at L M N assumes the character of a purple clay enclosing large unrolled fragments of the Eocene beds and small pieces of chalk. The Woolwich shell-bed, with the pebble-bed, is visible *in situ* at the south-west corner of the ballast-pit at Erith Station, at a height of 60 feet above the chalk, the whole series of Thanet sands being exposed there below it. It is probable that the escarpment of Thanet sands and chalk is only a little to the west of M. It is evident that this particular mass (*b*, fig. 21), must have been, when *in situ*, at least 110 feet above the Ordnance datum-line; for part of the pebble-bed is still attached to it, and that pebble-bed is 60 feet above the basement-bed of the Thanet sands, which sands would be, if *in situ*, 50 feet above the datum-line at the point M, according to my calculation. The positions of the top and bottom of the Thanet sands can be determined, as they are visible *in situ* between J and I, and also along the face of the chalk-pit between G and E.

The difficulty is, to understand what kind of wash of water removed this incoherent mass of Thanet sands and deposited it again (without breaking it up into sand) 35 feet lower down, upon a mass of the Woolwich shell-bed (*c*), which must have descended 45 feet and changed places with *b*.

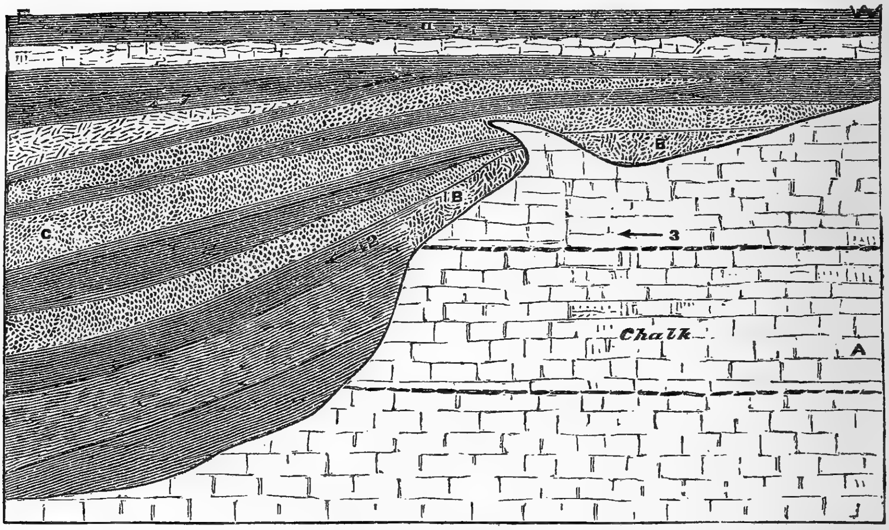
As the Thanet sand has been removed from the large area of chalk to the west, the mass of sand (fig. 21) may have been derived from a distance.

The Thanet sands before their denudation dipped towards the north, from the Kentish hills to Erith, at a slope of 1 in 100 on an average of ten miles. It may have been owing to the existence of a rainy period, and to high land to the west, that water could have moved the Thanet sands. Eastward, towards the low ground near the Thames, on the opposite side of the river, at Grays, I have only seen one small mass of Thanet sand imbedded in the covering gravel (*e*) near F, Plate VII.; but to the east of Grays the chalk soon dips eastward *, and therefore falls below the level of the river; so that there was no high land to give transporting-power and velocity to the water that fell upon it. The nearest English deposit in physical character, and perhaps in age, to that represented in fig. 21, is at Cromer. It is also probable that without the high background near Cromer such a deposit as that in the Cromer cliffs could not have been formed. The great mass of chalk at Trimmingham is an instance of an unbroken rock having been detached and moved down to a lower level in the Quaternary period, and enveloped in clay of a different formation. The stratified fossiliferous gravel on the Norfolk coast has been tranquilly deposited in front of, or near, the great slipped masses

* And northward.

of what is there called boulder-clay, just as the stratified fossiliferous gravels at Erith are close to and interstratified with the non-remanié but moved Tertiaries at Erith.

Fig. 22.—*Section in Crayford Pit.*



This section is to natural scale, but is reversed.

The basement-bed of the Thanet sands and a few feet of the sands are exposed along the face of the cutting, A C, Plate VI. The surface of the chalk is seen to be eroded by chemical action into pipes and basin-shaped cavities. The Thanet sands are broken through and moved into the pipes in the usual manner, and are covered by a top bed of sand and gravel, which fills up all the hollows of the underlying sands and chalk, and smooths over all previous inequalities.

The beak of chalk under *a* has protected small masses of Thanet sands (B and B′) below and behind it from being remanié and mixed up with the gravel. The covering bed of sand and gravel is smooth and nearly horizontal. *c* dips at 10° towards the Thames, and in one point at 12°. The chalk near A is 70 feet above the Ordnance datum-line, although only 50 feet is shown here. At P, Plate VI., 400 feet to the south-east, the chalk is seen in a pond only 10 feet above the Ordnance datum-line.

The inclination of the escarpment between C and P is 1 in 6, or 15° on the average; and this is entirely due to the excavation of the channel by the ancient River Thames. The lowest bed exposed in fig. 22 consists of from 3 to 4 feet of coarse gravel lying on the eroded chalk.

Fig. 23 represents rather higher ground; and 15 feet of Thanet sands are seen *in situ* (*b*). The gravel and brick-earth are well seen, dipping as much as 22° east at the steepest point.

The covering bed of sand and gravel, 5 feet thick (*a*), lies on the edges of the gravel (*c*) and brick-earths, and slopes to the river at a gradient of 1 in 25 in that part. Only 48 feet in height is shown in fig. 23. The sketch is to natural scale; so that the angles of the escarpment of chalk are not exaggerated.

Fig. 23.—*Section in Crayford Pit.*

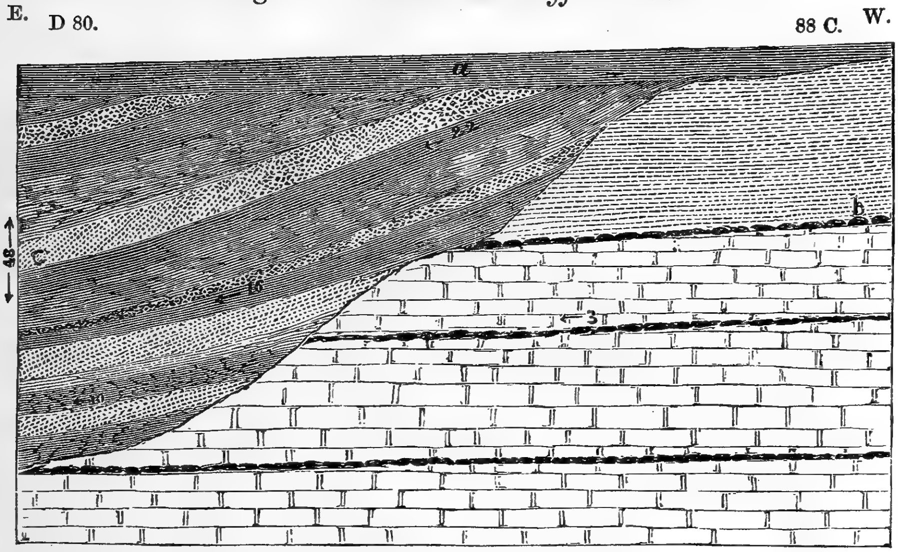
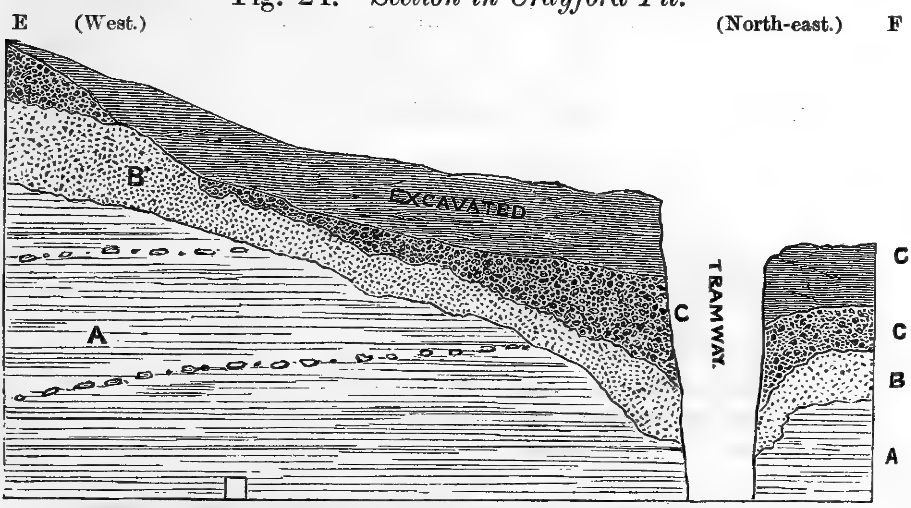


Fig. 24 is a view near the curved line E F, of the eroded surface of the chalk (A), with rearranged Thanet sands (B) 4 or 5 feet thick,

Fig. 24.—*Section in Crayford Pit.*



enclosing large flints from the basement-bed. The deposition of 6 feet of coarse flint-gravel (C), on the bed B, in a hollow of the chalk excavated prior to the gravel-period, is well exposed just where the tramway cuts through it.

The brick-earths above the gravel have been excavated. The brick-earth generally is more valuable than the sand and gravel, and the workmen often leave the lower beds in the state shown in fig. 24

for a long time. The chalk is excavated at the tramway to 20 feet above the Ordnance datum-line, and is 55 feet high at E, where the Thanet sands (B) are nearly *in situ*.

The curve in the line of section gives an appearance of flexure to the veins of flints in figs. 24 and 25 which does not really exist. These bands are not far from horizontal.

Fig. 25.—*Section in Crayford Pit.*

T (S.W.). U (N.E.).

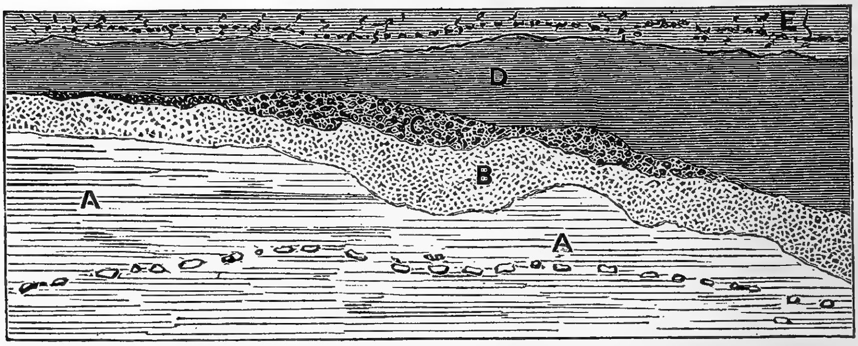
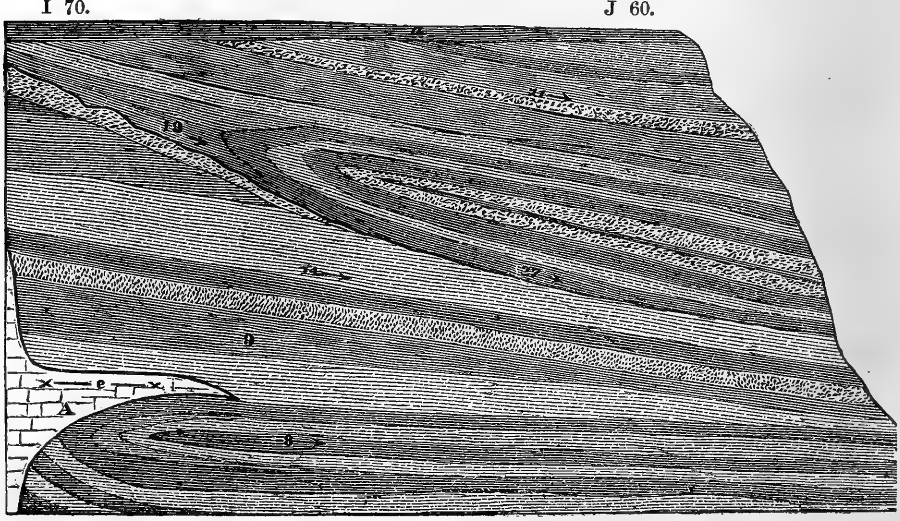


Fig. 25 is along the line T U, Plate VI., and shows the eroded surface of the chalk in an oblique direction to the old river-channel. The gravel (B) is very conspicuous, and the brick-earth series (D) is thinner than usual; but this is due to the distance of U from the escarpment. To the east of U the brick-earths gradually thin out, and the upper and lower gravels unite, forming a bed of coarse gravel 8 or 10 feet thick lying on the chalk. The height of the point T is about 40 feet, and the chalk under U about 20 feet, above the Ordnance datum-line.

Fig. 26, a section along the line I J, offered good opportunities

Fig. 26.—*Section in Crayford Pit.*

W. E.
I 70. J 60.

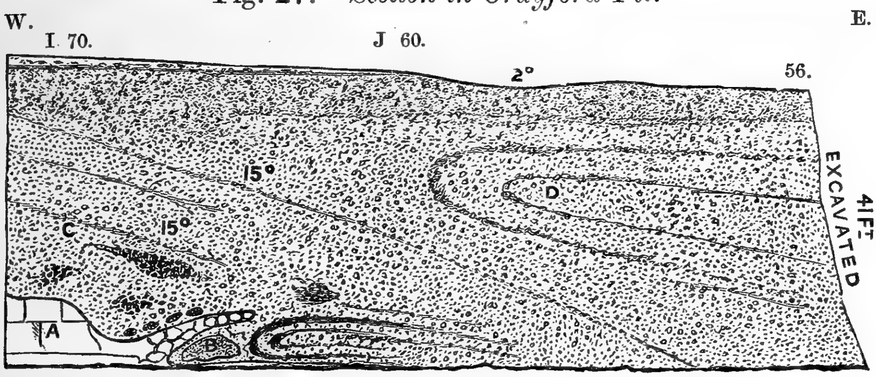


for examining the dip of the gravel, and showing the relation of the thick brick-earth beds deposited at angles as high as 19°, 17°, 14°, 11°, and 9°, in curves falling to the river. The beak of chalk is shown at about 18 feet above the Ordnance datum-line. It is about 10 feet long; and the junction with the escarpment of chalk is not seen.

This drawing is by Mr. S. Skertchly, to natural scale.

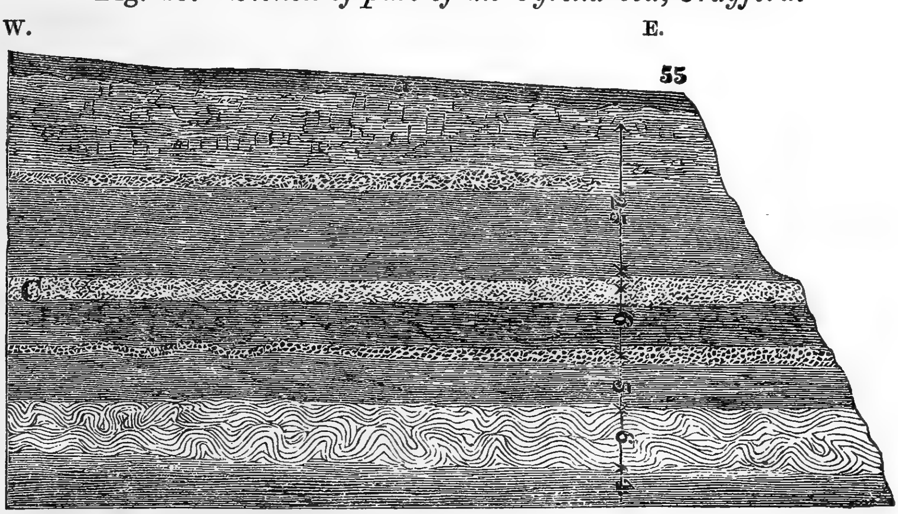
Fig. 27 is from a drawing I made in 1866, near the line I J.

Fig. 27.—*Section in Crayford Pit.*



The mass of Thanet sand B, below the beak of chalk near A, was then well seen; patches of these sands also occur in the brick-earths and gravels C. The dip was 15° where marked, and that of the covering bed only 2°. Fig. 27 is to natural scale, and represents a greater length of section than fig. 26. This part of the pit has recently

Fig. 28.—*Section of part of the Cyrena-bed, Crayford.*

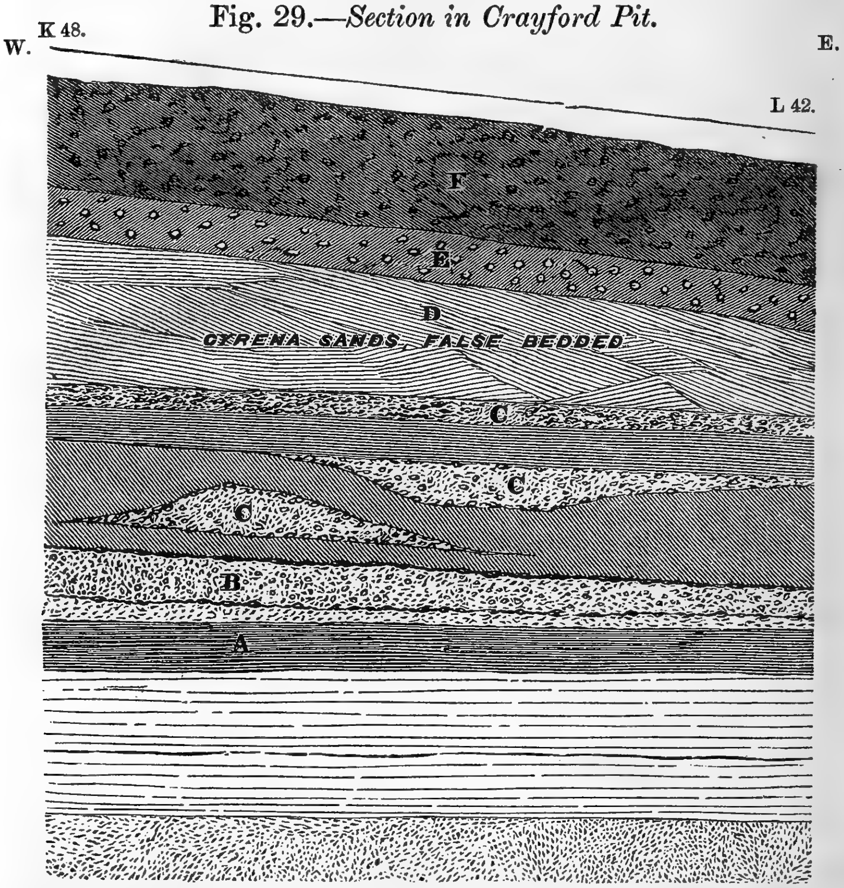


been excavated; so I give both sections for reference. The coarse gravel in front of the beak is pushed out horizontally into the finer beds of sand, and divides into fine points. There were other beaks of chalk visible at G and H.

Fig. 28 is a careful sketch of part of the Cyrena-bed, by Mr. S. Skertchly. The section is as follows, in ascending order:—sands 4 feet, wavy laminated brick-earth beds 6 feet, brick-earth 5 feet, a bed of pebbles from the Woolwich series, brick-earth, and clay 6 feet; the Cyrena sand-bed, C, passing upwards into laminated brick-earth, gravel, and loam, 25 feet thick.

Fig. 29 is a section of the most fossiliferous part of the Crayford pit,

Fig. 29.—*Section in Crayford Pit.*

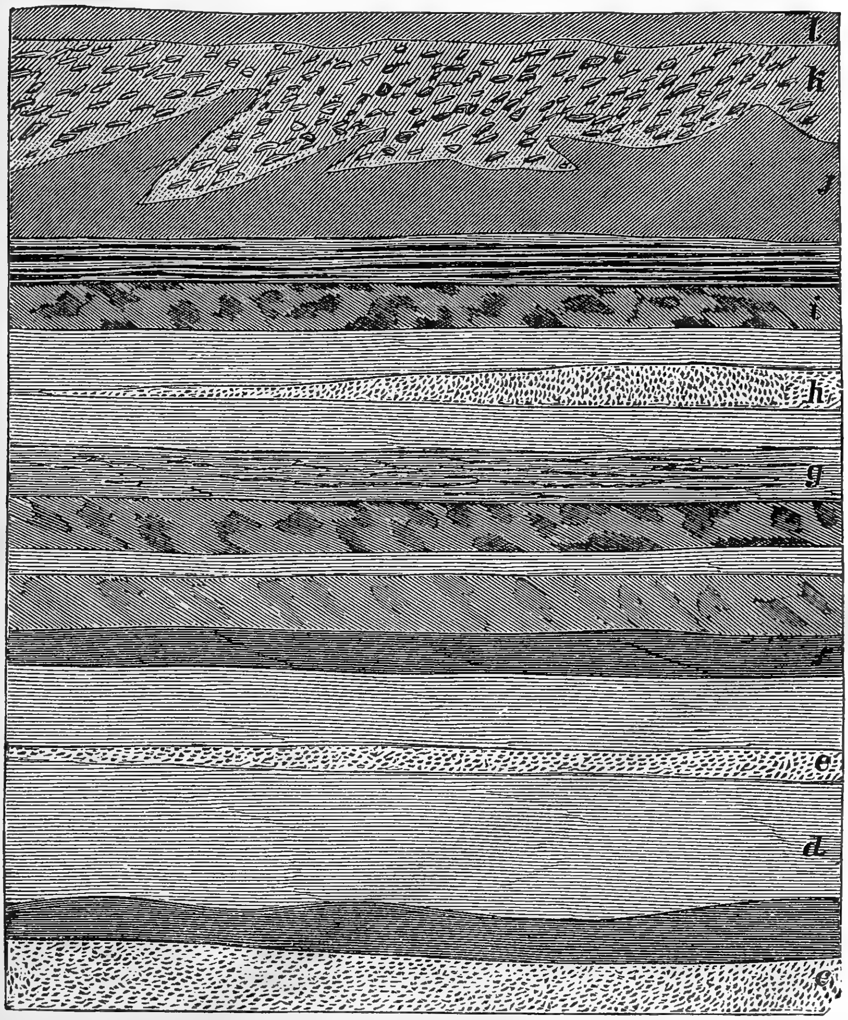


along the line K L (see Pl. VI.). It represents about 30 feet in height by 150 in length; so that the horizontal scale is about five times the vertical. It is intended to show the variation in the pebble-beds, C, and the thickening of the whole series in the direction of the escarpment. The pebble-beds, C, are in three divisions, and the great Cyrena-bed, D, rests on one of them; but shells are found in B, C, D, and E, though not in the covering bed F, which contains flint-pebbles distributed through it in the usual manner. The lowest beds are not seen in fig. 29; but at X, near M N, there are several openings at a depth of 35 feet from the surface, where a bed of coarse gravel is visible, which is near the eroded surface of the chalk. The chalk itself, with a covering of gravel or sand, is seen in the ponds marked P in the Crayford pit, where the water stands a little below the level of high water.

The Cyrena-bed varies from 4 feet to 6 feet (D, fig. 29) in thickness, and consists of false-bedded sand containing a great number of small and delicate shells in a perfect state of preservation.

Fig. 30 exhibits the series of gravels in the Stoke-Newington pit,

W. Fig. 30.—*Section in Stoke-Newington Pit.* E.



which is 43 feet deep. The bottom consists of yellow false-bedded sands, passing upwards into a series of stratified brick-earths and clays with veins of gravel. The covering bed, *k*, is indented into the brick-earth, *j*; it is from 6 to 8 feet thick, composed of large flints in stiff brown clay, and forms a marked contrast to the finely laminated loams and clays forming the 30 feet below it, *c–k*. The bed *f* is a black peaty clay; and the shells in the list from Stoke Newington are found in brick-earth and clay above this black bed in the adjoining pit. The covering bed reaches a height of 125 feet above the Ordnance datum-line, and is within 300 yards of the escarpment of the London Clay to the north. Where the London Clay is visible to the north,

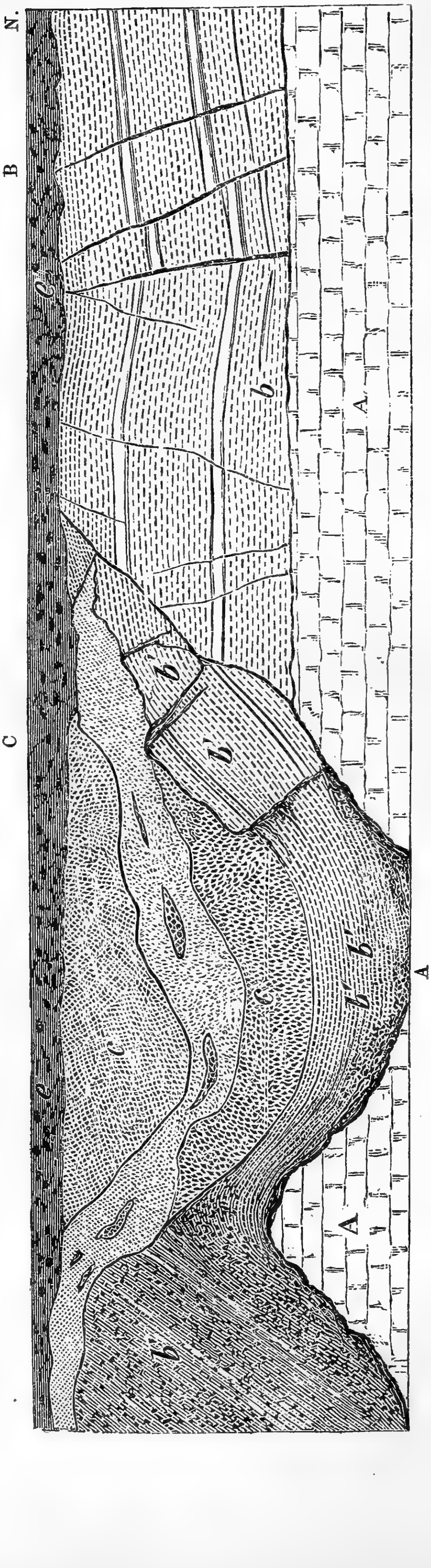


Fig. 31.—*Section at Grays, illustrating the rearrangement of the Thanet Sands in Pipes in the Chalk near* L, Plate IX.

at a height of 140 feet, it is only covered by 6 feet of gravel, while in fig. 30 it is covered by about 50 feet of the Quaternary series.

Fig. 31 is a drawing to natural scale, showing the relations of the Thanet sands to the covering bed of gravel, where these sands have fallen into pipes in the chalk. The Thanet sands have not been faulted by any general movement, but have dropped down where they have been undermined by the removal of chalk by chemical action.

It would appear as if this chemical action had been contemporaneous with the denudation of the Thames-valley district by pluvial and fluvial agency, and had preceded the deposition of the covering bed of sand and gravel. The proof of this is that the fissures in the sand are filled by veins of gravel from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inch wide to a great depth.

When the sands fell by gravitation into the great pipe (A), (which penetrates the chalk 25 feet, and the Thanet sands an equal amount), they filled it up to a height of 20 feet. This must have left a large funnel-shaped hole on the surface of the sands. It will be seen that, although the gravel is only 5 or 6 feet thick over the undisturbed sands at B, it has been able to fill a cavity 30 feet deep in the Thanet sands and chalk; and yet the top of the gravel is so smooth that no one could tell from the appearance of the surface that such a cavity had existed. There must have been a wash of gravel all over the sand to have furnished the material to fill up such cavities as that shown in fig. 31; and since that wash of gravel there is no indication of any subsequent deepening of the pipes in the chalk.

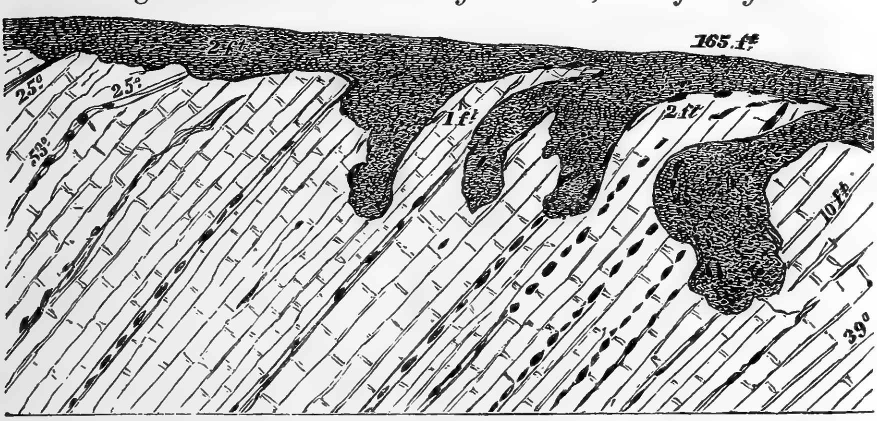
The Thanet sands (*b*), 25 feet thick at B, at the north of fig. 31, are seen lying *in situ* on the chalk.

Where the formation of the great pipe A has undermined the Thanet sands, *b*, the latter have fallen down to the bottom of the pipe A, which is funnel-shaped, and filled up 20 feet without any mixture of gravel whatever. The sands moved from their proper position are indicated by the letters *b′ b′*; the bottom part of the pipe A is not shown in this drawing. Under C, masses of sand, *b b*, are shown falling into the pit by gravitation, from the removal of the chalk by chemical action. The gravel series *c c* is 30 feet thick above A, and is similar in mineral character to the covering bed *e*.

Mr. Prestwich has explained the formation of pipes by chemical agency in the chalk.

Fig. 32 is a drawing of other beak-like projections in the chalk

Fig. 32.—*Section near Knighton Mill, Isle of Wight.*



where it has been acted upon by denudation previously to the deposition of the gravel near Knighton Mill, Isle of Wight.

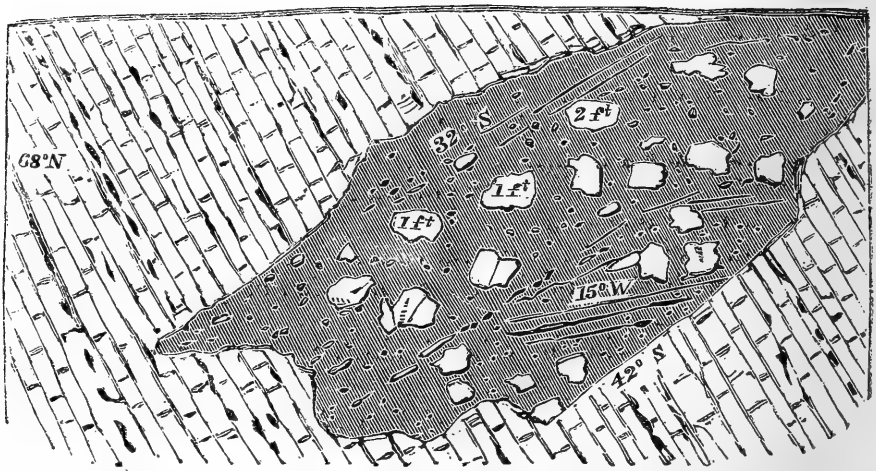
Fig. 33 (p. 98) is a section of a fissure or pipe in the highly inclined chalk on Brading Down, Isle of Wight, which is a remarkable contrast to the ordinary pipes which are filled with sand or gravel.

The general conclusions to be drawn from the sections of the Thames-valley fossiliferous deposits appears to be that they are a series of variable sands, loams, and clays intercalated between the upper and lower gravels.

The false-bedded sands are below the loams and clays at Erith, and above them at Grays, while at Crayford they are in the middle of the series. This may simply arise from the principal current changing from one side of the old river to the other during the deposition of the Thames Quaternary series. By this means, where the current became more rapid, sands would be deposited, and where the current was reduced, the finer materials might be deposited. There is no evidence of any change of level during these deposits; and the river must have risen 50 feet at least in times of flood.

Fig. 33.—*Sect on on Brading Down, Isle of Wight, showing blocks of Chalk in Gravel.*

S. 245. N.



In conclusion I may mention that the beds described above as pluvial have been referred to by Mr. Godwin-Austen under the name of Head, or Subaerial beds; and I quite admit the propriety and importance of his terms in many respects; but I was obliged to use the term "pluvial," in order specially to introduce the notion of rain-water action, as I was treating of deposits made on slopes by the action of water (probably by a non-continuous action) and thus necessarily to be separated from the ordinary aqueous action, such as is performed by rivers, lakes, and seas; as well as from ordinary subaerial action. While the pluvial beds, as I have shown in my sections, pass down into the aqueous beds, they pass upward into Mr. Godwin-Austen's subaerial beds, and the stones which have been *head* at one time, and weathered by subaerial action, pass down into what may be termed pluvial beds, which in their turn are being constantly despoiled, and carried into the purely aqueous beds at lower levels. Although Mr. Godwin-Austen's term subaerial is an excellent one, I submit that it does not sufficiently define the kind of action for the purpose I have in view, and still less so for the paper I have prepared on the formation of valleys, and the denudation of the surface.

When the Crayford and Erith beds have been as fully examined as those at Grays, the numerical superiority of the Mollusca in the latter deposit (as shown in the following Table) will probably disappear.

The list of shells from Salisbury is principally on Dr. Blackmore's authority. The Grays list is compiled from Mr. Pickering's table, the Ilford one partly from Mr. Morris's; the remainder by Mr. A. Bell, who has revised the list, and omitted the doubtful species.

The list from the Stoke-Newington fossiliferous pit, discovered by me in 1868, has been prepared by Mr. J. Wood Mason, F.G.S., who has added several species to the list first published.

The Land and Freshwater Mollusca of the Fossiliferous Gravels at localities referred to in this Memoir.

Species.	Grays.	Ilford.	Erith.	Crayford.	Stoke Newington.	Salisbury.
Achatina acicula, *Müll.*	*?					
Ancylus fluviatilis, *Müll.*	*	*	*	*	*	*
Anodonta cygnea, *Linn.*	*	*	*	*		
Balæa fragilis, *Drap.*	*?					
Bithynia tentaculata, *Linn.*	*	*	*	*	*	*
Carychium minimum, *Müll.* ...	*	*	*	...	*	*
Clausilia biplicata, *Mont.*	*	...	...	...	*	
Cyclas cornea, *Linn.*	*	*	*	*	*	
Cyrena fluminalis, *Müll.*	*	*	*	*		
Helix arbustorum, *Linn.*	*	...	...	...	*	*
—— concinna, *Jeff.*	*	...	...	...	...	*
—— fulva, *Müll.*	...	*				
—— hispida, *Linn.*	*	*	*	*	...	*
—— nemoralis, *Linn.*	*	*	*	*	*	*
—— pulchella, *Müll.*	*	...	...	*	*	*
—— pygmea, *Drap.*	*	...	...	...	...	*
—— rotundata, *Müll.*	*					
—— ruderata, *Stud.*	*					
—— rufescens, *Pen. (Morris)* ...	*	...	...	...	*	*
—— (Zonites) crystallina, *Müll.*	...	...	...	*?		
—— (——) nitidula, *Drap.*	*	...	...	*		
—— (——) radiatula, *Ald.*	*	...	...	*		
Hydrobia marginata, *Mich.*	*	...	*	*		
Limax agrestis, *Linn.*	*	...	...	...	...	*
—— marginatus, *Müll.*	*					
Lymnæus auricularius, *Linn.* ...	*	*	...	*		
—— palustris, *Müll.*	*	*	...	*	*	*
—— pereger, *Müll.*	*	*	*	*	...	*
—— stagnalis, *Linn.*	*	...	...	*		
—— truncatulus, *Müll.*	*	*	...	*	*	*
Paludina	...	...	...	*		
Pisidium obtusale	...	...	...	...	...	*
—— amnicum, *Müll.*	*	*	*	*	*	
—— fontinale, *Drap.*	*	*	*	*		
—— pusillum, *Gmel.*	*	...	...	...	...	*
Planorbis albus, *Müll.*	*					
—— carinatus, *Müll.*	*	...	*	...	*	*
—— complanatus, *Flem.*	*	...	...	*	*	
—— contortus, *Müll.*	*	...	...	...	*	
—— corneus, *Linn.*	*	*	*	*		
—— glaber, *Jeff.*	*	...	...	...	*	
—— nautileus, *Flem.*	*					
—— nitidus, *Müll.*	*	...	...	...	*	
—— spirorbis, *Müll.*	*	...	...	*	*	*
—— vortex, *Müll. (Morris)*	...	...	*			

Table (*continued*).

Species.	Grays.	Ilford.	Erith.	Crayford.	Stoke Newington.	Salisbury.
Pupa marginata, *Drap.*	*	*	*	*	...	*
—— umbilicata, *Drap.*	...	...	...	...	*	
—— (Vertigo) antivertigo, *Drap.*	*	*				
—— (——) pusilla, *Müll.*	*					
—— (——) substriata, *Jeff.*	*					
Succinia putris, *Linn.*	*	*	...	*	*	*
Unio litoralis, *Lam.*	*	*	...	*		
—— pictorum, *Linn.*	*	*	...	*		
—— tumidus, *Phil.*	*	*				
Valvata cristata, *Müll.*	*	...	...	*	*	
—— piscinalis, *Müll.*	*	*	*	*	*	*
Zua lubrica, *Müll.*	*	*	...	...	*	*
Velletia lacustris, *Müll.*	*	...	...	...	*	

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 23, 1868.

The Rev. J. F. Blake, M.A., Gonville and Caius College, Cambridge; Thomas Sparke Parry, Esq., Castlebar, Ealing, Middlesex; and William H. Penning, Esq., of the Geological Survey of England, 28 Jermyn Street, W., were elected Fellows.

The following communications were read:—

1. *On the so-called* "Eozoonal" Rock. By Prof. W. King and Dr. T. H. Rowney.

(Communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.)

[Abstract.]

The authors noticed that, since the reading of their former communication in 1866, further descriptions of *Eozoon* have been published by Hochstetter, Gümbel, Carpenter, Dawson, and Logan; and after a few words on those by the first two, they proceeded to criticise the others more fully, intimating that the English and Canadian observers have by no means mastered all the difficulties of the subject, nor answered the objections brought forward by them. In the course of these remarks, Messrs. King and Rowney, objecting to the specimen from Tudor, of which they have seen the photograph, and which was described and figured in 1867*, suggested that it is nothing more than the result of infiltration of carbonate of lime, with entangled impurities, between two layers of the sandy limestone. They also stated their belief that the term "Eozoonal" is applicable to any of the ophites they describe, inasmuch as, it was contended, the

* Quart. Journ. Geol. Soc. vol. xxiii. pls. 11 & 12.

structure of the latter is similar to that of the Canadian rock containing the so-called *Eozoon*.

The authors then proceeded to treat of the supposed *foraminiferal* characters of "Eozoon." First, as to the "cell-wall" or "nummuline layer," they advanced repeated evidence of the value of their former proofs that the typical form is due to aciculate serpentine (or modified chrysotile) of inorganic origin—having examined, besides others, a Canadian specimen presented by Dr. Carpenter. Secondly, nothing new was adduced with regard to the mineral structure of the so-called "intermediate skeleton." Thirdly, in proof that the "chamber-casts" are not of organic origin, the authors referred to their former work, and stated that chondrodite and pyrallolite may be added to the list of minerals that occur, as such, disseminated in limestones. They thought it strange that a carbonate, as well as a silicate, should not have been found filling the so-called chambers; and they decidedly refused to accept the Tudor specimen having some tubuli filled with calcite, to which they suppose Dawson refers when speaking of chambers filled with calcite, as a case in point; they were unacquainted with any published instances of this mineral being an infilling. Fourthly, reiterating their observations on the so-called "canal-system," they suggested that the globoso-vermicular bodies noticed by Dawson and Gümbel may be metaxite; and they insisted on the difficulty of explaining the presence of isolated unbroken tube-casts in patches of pure limestone. The Madoc specimen, described by Dawson as having its "canals" and "chambers" filled with calcite, was next referred to; and it was argued that the so-called calcite, both in this and in another specimen, described by Carpenter, is doubtful and not proved; for the authors had not been able to confirm the accuracy of the observations in these cases, having examined a Canadian specimen, presented by Dr. Carpenter as an example of the kind, which had in it "homogeneous and structureless forms of the canal-system" that were not dissolved in the decalcification. Fifthly, the organic nature of the so-called "stolons" was regarded as quite disproved. *Mineralogical* considerations of Eozoonal rocks were next entered upon; and from the study of Canadian specimens, and of others from Connemara and Bavaria, described in full, the authors concluded that they fully prove the "canal-system," "chamber-casts," and "nummuline layer" to be structural and inorganic modifications of serpentine—that the whole have originated from the change or waste of granules, plates, &c. of serpentine; and they incline to the belief that the calcite of the "intermediate skeleton" is pseudomorphic after one or other form of serpentine by infiltration and replacement. The rounded form of the granular masses of chondrodite, coccolite, &c. in some limestones was also referred by the authors to the gradual removal of their surfaces by deep-seated hydrothermal agency.

It was then argued that the organic nature of *Eozoon* cannot be supported by the cumulative evidence afforded by the combination of foraminiferal features; for these features, *combined* and due to purely mineral paragenesis, had occurred to the authors in certain ophites, though some are wanting in other ophites, just as they are not always present in the Eozoonal rock of Canada.

Serpentine has been described as having been deposited in the cavities of Eozoon, and having taken the place of its sarcode; but the authors criticised all the quoted analogies of such a precipitation of any siliceo-magnesian substance, which they disbelieve, and put aside glauconitic infiltration as beside the question.

Considered *geologically,* with referrence to its occurrence in a metamorphic rock, the authors regarded the *Eozoon* as an organic impossibility; and they asked why it should never be found in anything but crystalline or semicrystalline rocks—in ophites or ophicalcites of widely different ages. Particularly they found eozoonal structure in the Liassic ophite of Skye; and this they described in full. They criticised Sterry Hunt's change of opinion, who used to think that the serpentinous rocks of Canada were once earthy amorphous silicates, and afterwards metamorphosed, but who now supposes they were deposited in a crystalline state; and they asked why, if so, may not all the Laurentian rocks have been so deposited? In conclusion, they totally denied that Eozoonal structure has anything to do with any organism, and repeated that, like all analogous conditions of serpentine, chondrodite, &c., it is of purely mineral origin.

DISCUSSION.

Prof. RAMSAY had been struck long ago by the organic appearance of the structure now regarded as *Eozoon.* He had also felt a difficulty in accounting for the existence of large masses of limestone, except by the operation of organisms living in the sea, in which such deposits had been formed. He could not imagine the sea-water so overcharged with calcareous matter as spontaneously to deposit limestone.

Mr. PARKER, on examining the various parts of the *Eozoon* as shown him by Dr. Carpenter, had been able to recognize in them similar structures to what he had already met with in recent Foraminifera.

Prof. T. RUPERT JONES accounted for the difficulty that sometimes existed in recognizing Eozoonal structure by the contortion of the containing beds subsequently to their deposition.

Dr. DUNCAN had been struck in the earlier known specimens of *Eozoon* by the shape of the tubules of the canals: he had never seen similar outlines in inorganic bodies.

Dr. CARPENTER need not repeat the grounds on which he regarded *Eozoon* as an organic structure. He objected to criticisms unless founded on examination of actual specimens, and regretted that Prof. King had not examined the large collection of specimens in his (Dr. Carpenter's) collection. A specimen which Sir William Logan had brought from Canada contained much iron, and had the Canal-system wonderfully preserved; and it presented this character—that the larger branches were infiltrated with serpentine, and the middle branches with sulphide of iron, while the smallest branches were filled with carbonate of lime, of the same nature as the matrix. It was only under a favourable light that these smaller tubes were visible, as the calcite in them was of the same crystalline character as the surrounding network. This was conclusive evidence of the structure not arising from the mere infiltration of one chemical substance into another. Moreover such an infiltration would have passed *between* the cleavage-planes, instead of running *across* them as the Canal-system does. When cut, some specimens had given out a strong odour of musk, which they to some extent still retained; this, again, seemed to be evidence of organic origin. The manner in which the authors speak of the Canal-system and of the nummuline layer satisfied him that they have depended on the evidence of *decalcified specimens,* and have not made themselves sufficiently acquainted with the appearances presented by *transparent sections.* If they had done so, they could not have continued to assert that the nummuline layer is nothing else than chrysotile—the characters of the two being totally different. Recent Foraminifera, when decalcified, exhibited precisely the same asbestiform layer round the chamber-cast as the fossil *Eozoon.* In the deep seas of the present day, at various depths and temperatures, was a large extension of sarcodic substance; and in this there were Rhizopods with and without shells, but of similar low structure; and such forms might have continued in existence through any length of time, so that the occurrence of *Eozoon* so far down as Jurassic times could afford no matter for surprise. He should not be astonished even if such a structure as *Eozoon* were found in deep-sea dredgings of the present day.

The President mentioned the *Bathybius,* which he has found with coccoliths and other forms in deep-sea soundings. In some newer specimens of Atlantic mud given him by Dr. Carpenter he had found *Bathybius* forming a sort of network, somewhat similar to the plasmodia of botanists. He could not call it either plant or animal. It was, however, a living substance, susceptible of apparently indefinite growth. This removed one of the difficulties in believing in the wide extension of the *Eozoon.* The Hydrographer to the Admiralty had since sent him the soundings taken by Captain Shortland in 'The Hydra.' In soundings from 2800 fathoms in the Arabian Gulf *Bathybius* was plentiful; and over an area 7000 miles long the same organism occurred in abundance. He agreed in thinking it possible that such organisms might have gone on living from the earliest geological times.

In answer to Prof. Ramsay, the President stated that the soundings in which the *Bathybius* occurs alone, as analyzed by Dr. Frankland, contained $1\frac{1}{2}$ per cent. of nitrogenous organic matter.

2. *Notes on the* GEOLOGY *of* CHINA, *with more especial reference to the* PROVINCES *of the* LOWER YANGTSE. By T. W. KINGSMILL, Corr. Sec. North-China Branch of the Royal Asiatic Society.

[Communicated by the President.]

So far as I am aware, no attempt has been as yet made to classify the several geological formations of this huge empire. Isolated accounts of small sections have, indeed, appeared, but these for the most part were the productions of travellers inexperienced in the nomenclature of the science. Two exceptions, however, may be mentioned: one of these is Mr. Raphael Pumpelly, who in the years 1863–5 examined the coal-beds of the north-eastern provinces; the other, Mr. A. S. Bickmore, who in the year 1866 penetrated from Canton by Kwangsi and Hunan to Hankow in the centre of the empire. Unfortunately Mr. Pumpelly, so far as I know, has published no full statement of his researches, the only account being a short notice in Silliman's Journal in 1866, which, unluckily, I have not had the opportunity of perusing in full; while Mr. Bickmore's stay was too short, and the restrictions imposed on him during his adventurous journey too severe, to have afforded him the opportunity of forming a regular classification. I shall in the course of this paper, however, allude to some very interesting observations of his, detailed in a paper read before the North-China Branch of the Royal Asiatic Society, and published in the volume of their Transactions for last year.

My own personal observations have been made during a residence of nearly seven years, distributed between Hongkong, Canton, Shanghai, and Hankow, having had besides the advantage of occasional visits to all the open ports in the South of China, from most of which I have made excursions into the country lying around. In January of the present year (1868) I spent some ten days in the inspection of the country situated in the neighbourhood of Nanking and Chinkiang, which afforded me some valuable results, while other tours have made me tolerably well acquainted with the districts of Lower Kiangsu, of southern Nganhwei, and of the districts of Kiangsi and Hupeh adjacent to the river Yangtse.

Excluding the provinces of Fuhkien and Chehkiang, which probably offer some partial exceptions, the aqueous formations of the south of China commence at bottom with a series of coarse grits and sandstones overlain conformably by limestones and shales. This formation extends from the east coast far into Hupeh, and apparently to the west of Sz'chuen, and from the south of Kwangtung certainly as far north as the basin of the Yangtse, and probably far into Mongolia. Throughout all the districts with which I am acquainted it occurs in vast synclinals and anticlinals, forming a series of mountain-chains rising generally to no great height, though in the Mei-ling between Kwangtung and Kiangsi, in the Wue-shan between the latter province and Fuhkien, and in the Lu-shan near Kiukiang on the Yangtse it seems to exceed the altitude of 5000 feet. In fact it may be said to form the skeleton of the country, the succeeding formations occurring for the most part in the valleys and depressions of the older series, which forms, in the south of China at least, the main geological framework of the empire. These rocks are throughout much broken up by faults, the softer portions denuded forming valleys, and then again for the most part filled up by deep deposits of subsequent date. In the valley of the Yangtse the strike generally approaches within a few degrees of E. and W.; in the southern provinces it is commonly from E.S.E. to W.N.W., or thereabouts; the strata are constantly either vertical or highly inclined. The series is of considerable thickness, probably from 16,000 to 20,000 feet, or even more. In the central provinces in Kiangsu and Kiangsi the following seems to be the sequence in descending order. From the circumstance of the greater portion of the series being developed in the two Tungting islands in the Taihu, within an easily accessible distance of Shanghai, I have given the formation the provisional title of the Tungting series for future reference.

No. 8.	Tungting series.	Limestones	Limestones	Probably 5000 to 6000 feet.
No. 7.			Calcareous shales	
No. 6.			Limestones and dolomites	
No. 5.			Lower coal and iron shales	About 600 to 800 ft.
No. 4.			Limestone with chert nodules	„ 800 feet.
No. 3.		Grits	Upper quartzites	12,000 feet.
No. 2.			Middle shales and shivery schists	
No. 1.			Lower quartzites	

The rocks composing this series are thoroughly conformable from first to last, and, as above stated, form the lowest formation I have hitherto been able to fix upon with certainty. They are for the most part destitute of fossils, though in one or two localities they have yielded a few specimens.

No. 1. The Lower Quartzites.—These rocks consist of coarse laminated quartzites or irregular sandstones, sometimes, as in Lower Kiangsu, altered into quartz rock, and occasionally, it is said, containing traces of gold. Occasional oval patches of a lighter colour and finer composition than the matrix occur; they are totally devoid of structure, but, from their occurrence in Kiangsu and Kiangsi at an interval of 400 miles, as well as in the intermediate district of Nanking, they seem to be characteristic.

No. 2. The Middle Shales.—This may be said to consist of an irregular mass of soft shales, sometimes, as in Lu-shan near Kiukiang, metamorphosed into purple slates of sufficient consistency to be made use of for water-cisterns, &c.; generally they form a mass of soft shales interspersed with a peculiar series of greenish schists, which split up into small angular spicula on exposure to the air. Though easily shivered into these small fragments, they persistently refuse further disintegration, and often form the surface for many hundred yards, these portions being almost entirely destitute of vegetation. These shales have yielded no fossils within my knowledge.

No. 3. The Upper Quartzites.—These rocks are in a great measure similar to those of No. 1, but are generally of more decidedly arenaceous character, in some of the upper beds forming fine-grained gritstones, much used by the Chinese for grindstones, set-stones, and

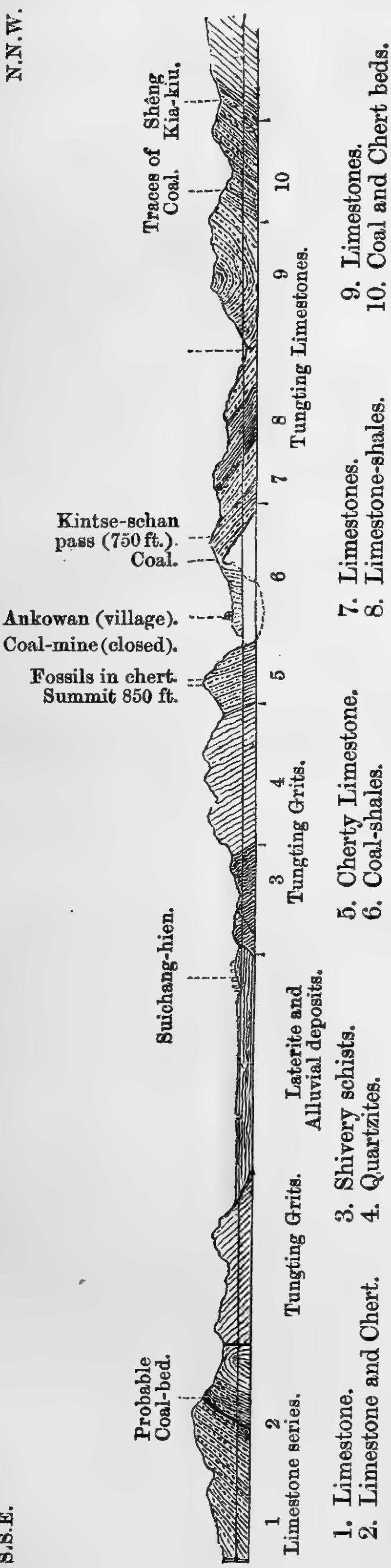


Fig. 1.—*Section of the Suichang Hills, Kiangsi.* (Scale 6 miles to 1 inch.)

their fine ink-stones. The extreme upper beds are more shaly, and have yielded fossils both animal and vegetable. I have met with but one locality for each, however,—the former, near Kiukiang, at the foot of the Lu-shan, the latter, in the Si Tungting-shan, in the Tai-hu. Of the former I have collected :—

Some doubtful fish-scales.
An Orthoceratite.
Two *Cirri?*
A *Gryphæa.*
A small doubtful conchifer.

The above, like most of the fossils of the Tungting series, are excessively badly preserved.

Of vegetable remains I have noticed the following :—

A *Lepidodendron,* with small lozenge-shaped reticulations.

Some stems of conifers, and possibly leaves of the same.

A *Pecopteris.*

Apparently two other forms not sufficiently well marked for determination.

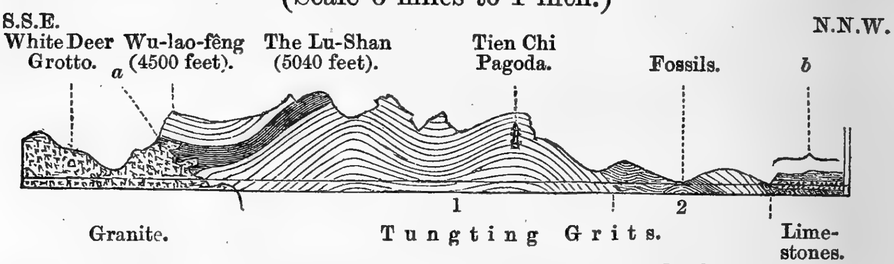
Fragments of leaves with parallel striæ.

The vegetable remains at least seem to indicate an early age for the containing rock.

These rocks, in the south of China, are eminently developed in the valley of the Si-kiang or West River, which rises in the frontier districts of Yunnan and Kwangsi, and, flowing on towards the delta of the Canton river, disembogues finally at the western side of the island on which is situated the Portuguese settlement of Macao. Mr. Bickmore describes them likewise as forming the foundation rock in the valley of the Kweikiang or Cassia

River, a tributary of the former flowing past Kweilin-fu, the capital of Kwangsi province. In the valley of Modo, near Soochow, in Kiangsu, a fine section is also exposed. The Lu-shan, a fine range of mountains near Kiukiang, commanding the entrance to the Poyang lake, is likewise composed of these rocks, which, moreover, appear at intervals through the entire district south of the Yangtse. In the island of Hongkong, and stretching along the sea-coast as far as the Chusan archipelago, they, much altered and associated with igneous rocks of various descriptions, form the main portion of the coast-range. Even in Hongkong itself an attentive examination discovers these slate rocks, but entangled with at least two series of plutonic rocks—one granitic, the other trachytic, and both evidently posterior to the sedimentary rocks. Near Soochow, likewise, in the Modo valley spoken of above, a mass of reddish granite rises from the midst of the lower shales, towards the axis of which the surrounding strata dip.

Fig. 2.—*Section of the Kiukiang district, Kiangsu.*
(Scale 6 miles to 1 inch.)



1 Quartzites. 2. Soft shales and schists.

a. Soft schists, converted into mica-schist and gneiss.

b. Limestone overlain by the Kiukiang laterite, with a base of coarse till containing small boulders.

At the Lu-shan the subsequent origin of the igneous rocks is also well displayed in the conversion of a portion of the superincumbent shales into mica-schist and gneiss; in Lower Kiangsu, likewise, the detached hills which appear over the surface of the alluvial plain are composed of the remains of these quartzites preserved from the denudation which destroyed the other portions of the series by the hardening effect of the intrusion of a series of porphyritic dykes having a general direction from W.S.W. to E.N.E.

Lying, as above stated, conformably over the Tungting grits, is a great mass of limestone, containing near its base, in the central provinces at least, a mass of shales of no great thickness producing coal and iron. Throughout the valley of the Yangtse, from the Taihu in Kiangsu westwards to the province of Hupeh, I have traced the lower bed, No. 4, of the series. This bed where exposed is rendered very conspicuous from projecting nodules of black chert jutting out far beyond the water-worn and often honeycombed limestone matrix; in fact one of the chief features of the series in the provinces of Kwangtung and Kwangsi is the extraordinary extent to which the solvent power of water has acted on the rock. In the valley of the

Si-kiang, in Kwangtung, the effect of the action of water on the limestone forms the characteristic feature of the landscape; the valley seems originally to have been formed by a wide synclinal curve of the whole series; except in a few spots, however, the whole of the limestone rocks have been washed away, leaving exposed the grits and slates of the lower beds. The appearance of these detached masses of limestone is described as very fantastic; of one, Mr. Bickmore writes as follows*:—" About two miles behind the city of Shadking-fu rise the famous marble rocks or 'Seven Stars,' like dark sharp needles out of the low green plain. Mr. Nevin and I measured them with an aneroid barometer, and found them to range from 100 to 150 feet above the plain, though they have been reported as nearly twice that height. The rock is a highly crystalline limestone, of a dark blue colour on the weathered surfaces, and of a rusty iron tinge where large fragments have been detached, the whole traversed in every direction with milk-white veins, and completely fissured by joints and seams." In this province, in many localities, these metamorphosed rocks are quarried, yielding ornamental marbles; some seem to be so highly altered as to afford a saccharoid marble, approaching in purity the statuary marble of Carrara; at the "Seven Stars" described above, a coarse marble marked with veins of graphite in zigzag lines is extensively quarried; it is much used throughout the province for paving, as well as for ornamental screens.

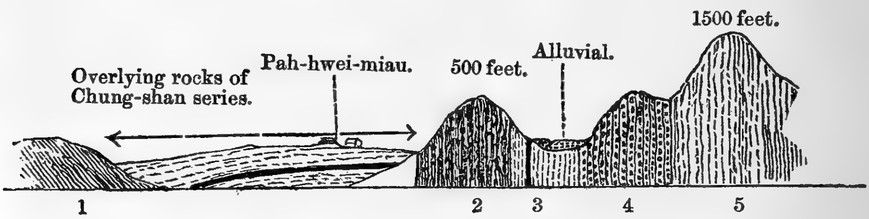
Other similar masses occur along the Si-kiang, near the town of Yueshing in the "Cock's-comb" rock, on the Tung-kiang in the east of the province in the "White-faced" rocks and the "White-horses," and on the Peh-kiang at the "Five Horse-heads," as well as at many unnamed localities. In Kwangsi on the Kwei-kiang or Cassia River, below Kweilin, the provincial capital, Mr. Bickmore thus describes their appearance†:—"On the evening after leaving Pingloh, as we were following the river round a high bluff, we suddenly found ourselves on the edge of a valley ten or twelve miles broad, and extending further than we could see, to the right and left; in every direction it was perfectly bristling with sharp peaks of limestone. The strata of this limestone were nearly horizontal; and once the whole valley was filled with this deposit, which in the course of ages has been worn into deep channels that have kept widening, until only sharp peaks are left of what was originally a broad continuous sheet of solid rock. From a single low position on the river bank I counted 192 separate peaks; the highest was, I judge, 1200 feet over the plain, but even this did not represent the original depth of the formation."

In the central provinces, though by no means so conspicuous, the effects of water on these rocks are still marked; the strike, as a general rule, approaches closely to an east and west direction, the folds of the strata continuing uninterrupted for many miles. The numbers 1, 3, and 4, containing the harder and more siliceous rocks,

* Journal of N. C. B. Royal Asiatic Society, New Series, vol. iv. p. 2.
† *Ib.* p. 7.

are found, as a general rule, forming the summits of the hills, while 2 and 5 almost invariably occur at the bottom of the valleys. In the Suichang district, near Kiukiang, of which a section is given (fig. 1), this arrangement is very marked; from the summit A, about 900 feet in height, and composed of the cherty limestone No. 4, the lines of hills running from W. by S. to E. by N. form a peculiar feature, the landscape appearing like a mass of petrified billows following in succession. At Nanking, as shown in the accompanying section (fig. 3), the series is similar; but in this district the limestone is largely converted into dolomite, No. 4, however, being precisely similar in both localities; here, however, no such perfect section is obtainable as at Suichang, and it seems doubtful in some spots whether the dolomite should be referred to Nos. 6 or 8. The strike in this district is almost due E. and W.

Fig. 3.—*Section of Coal-beds at Pah-hwei-miau in the Nanking district.* (Scale 4 miles to 1 inch.)



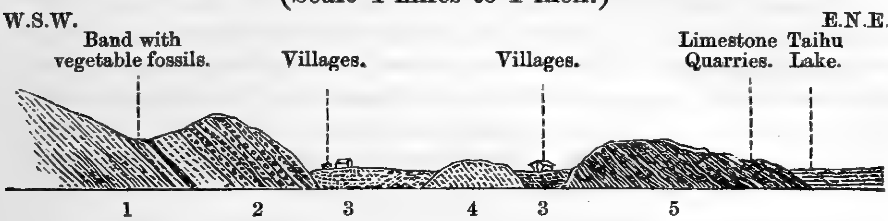
1. Grits.
2. Limestone, No 6.
3. Coal and Iron-shales, No. 5.
4. Limestone with chert-nodules, No. 4.
5. Shales and Grits, No. 3.

Proceeding eastwards for about 100 miles, we meet with the Tai-hu, a large lake in the prefecture of Soochow in Kiangsu province, which contains many islands composed of rocks of this formation. In two of these, the Tung and Si (East and West) Tungtings, the lower portion of the series is finely developed; in the eastern portion of one, the Si Tungting-shan, of which a section is appended (fig. 4), the limestones come in lying, as before, conformably over the grits and shales of the lower series. As in the other districts, the bed No. 4, containing chert nodules in large numbers, is conspicuous; further east for some distance a small alluvial plain interrupts the sequence, some low isolated hills seeming, however, to represent No. 5; while No. 6 appears further to the east in a bold promontory jutting out into the lake, where extensive limestone quarries have been worked for centuries.

These sections, with the foregoing description, will be sufficient to explain the general position and character of the lower sedimentary rocks of Southern China. As will have been seen, they are much disturbed, and in some localities altered by the intrusion of igneous rocks, which, especially along the coast chain from Macao to the Chusan islands, form in many localities the characteristic geological formation. Some of these localities have already been mentioned;

but in general, throughout the east and north-east of Kwangtung and the greater portion of Fuhkien, igneous and metamorphic rocks form the most conspicuous geological feature of the country. The

Fig. 4.—*Part Section of Si Tungting-shan.*
(Scale 4 miles to 1 inch.)



1. Grits and Shales, No. 3.
2. Limestone with Chert-nodules, No. 4.
3. Alluvial deposits.
4. Quartzose Shales, probably No. 5.
5. Limestone, No. 6.

granites of the coast-chain and of some inland districts, of Kwangtung and Kiangsi especially, give a forbidding aspect to the scenery where they occur. From the large amount of mica they contain, as well as from the excess of alkaline materials of the felspar, they are readily decomposed, and have yielded to the disintegrating action of the atmosphere (in these regions saturated with water for a large portion of the year) to an enormous extent, leaving behind a mass of soft unctuous clay surrounding the grains of unaltered quartz. The granite, however, is very concretionary in its structure and irregular in character; and here and there are to be seen large masses of solid stone, which have resisted decomposition and lie like enormous boulders imbedded in the surrounding matrix. In places exposed to the wear and tear of the tropical rains this matrix has been washed away; and the undecomposed masses left far and wide over the surfaces of the hills have more than once been referred to as the results of glacial action, corresponding with the boulder drift of more northern latitudes*. In many localities this decomposed rock, annually washed by the rains, assumes a most barren aspect, giving a blank and desolate appearance to the coast of the southern provinces as seen from the sea, deep channels worn by the mountain-torrents, and detached masses of every form scattered about, giving the whole an air of utter confusion. At Amoy especially may this be noticed, where the whole coast seaward presents a mass of white sandy hills glaring in a subtropical sun, and only relieved by the black of the detached boulders which lie around.

Granite, however, is not the only plutonic rock to be met with. In Kwangtung and Fuhkien large masses of porphyry of many varieties are found; trachytes containing a large portion of free silica are likewise abundant, as also large masses of greenstone. In Fuhkien large quantities of rock apparently felspar are found, of a fine grain and greenish colour, which form admirable building-stones. In Kiangsu and the Yangtse provinces granites and trachytes seem to form the characteristic igneous rocks.

* See Ansted's 'Elementary Course of Geology,' 2nd Edit. p. 42.

Though so largely composed of limestones, few fossils are to be met with in the upper beds of the Tungting series. I have collected, however, a few from No. 4 in the neighbourhood of Suichang, where they generally occur (though in bad preservation) in the chert nodules; in the Si Tungting-shan I have likewise met with a few in No. 6. The general complexion of the whole seems to be Devonian or Subcarboniferous; I have met with specimens of one species, apparently a *Rhynchonella*, from such distant localities as Kwangsi and the Taihu. Besides these I have met with the following fossils belonging to this formation, those marked with an asterisk, however, having been procured from medicine-shops and stated to be from Yunnan in the extreme S.W. of China.

At least one species of Orthoceratite. I have not been able to procure a specimen of these, as they are much prized by the Chinese under the name of "pagoda stones," and sold at fancy prices.

Euomphalus, a species closely allied to, if not identical with, *E. pentangulatus*.

Some internal casts, probably *Cirrus*.

Aviculopecten, probably *A. duplicatus* (Dana).

Fragments of other shells not recognizable.

Spirifer disjunctus, and four other species of the same genus.

Stringocephalus, three species.

Rhynchonella, as above.

Rhynchonella, two more species.

Rhynchonella (*R. pleurodon* ?).

Terebratula hastata ?

Athyris ? a species.

Orthis, two species.

A Trilobite.

Cyprididæ.

Cyathophyllum ?

Heliolites ?

Remains of Encrinites.

As I have no means of comparison with actual specimens, the above are merely put forward hypothetically; the fossils are few in number (those I have found mostly in bad preservation), but represent the results of a considerable time spent in the search.

Returning, however, to the rocks themselves, I have denominated No. 5 the "Lower Coal and Iron Shales." Containing, as they do in Kiangsu, enormous deposits of the metal, and being favourably situated for working, they bid fair to become of considerable economic importance so soon as the absurd prejudices of the Chinese Government permit of their being worked. I quote the following from a Report on the Nanking district, made by request of Mr. Markham, Her Majesty's Consul at Chinkiang, who has made energetic efforts to induce the provincial authorities to allow the mineral wealth of this district to be opened up.

"At Lungtan-chên, within the district, this series associated with Nos. 3 and 6 occurs; the dip here is towards the S.E., at an angle of about 60°. The coal-beds open out into a narrow valley, and have at one time been worked, but abandoned owing to difficulties attending the Taiping rebellion. In the neighbourhood of this place, in the Shênlung pass and in adjacent localities, a good deal of excellent iron ore, in the shape of hæmatite, occurs. Proceeding in a S.W. direction across the strike of the rocks, the coal-beds seem to be brought to the surface by a synclinal in the valley to the north of the Hwa-shan; the older rocks then reappear, forming in the mountain an anticlinal, and again dipping to the south form another valley filled for the most part with the later formations, but with the harder rocks still appearing at intervals in low detached ranges. To the south of this valley the series 4 and 5 again occur, the coal-bearing beds appearing at the side of a narrow valley S.W. of Pah-hwei-miau, beyond which, in a regular descending series, the lower beds again occur, running out in a long spur into the plain at the south (see section, p. 124).

"Although I have not noticed other outcrops of the coal-beds to the east of this line, I have no doubt of their occurrence, as the chert-bearing limestone is to be fonnd in several localities approaching within a few miles of Chinkiang. Near Chinkiang itself, at a place called Lui-shan, five miles distant, and also at another spot near Kaotsêh-chên, some fourteen miles away, this limestone seems to occur; the succeeding shales are ferriferous. At Lui-shan, in some detached hills, apparently belonging to this portion of the series, I collected some fine specimens of hæmatite; the beds cross the hill with a dip of about 60° towards the north; they seemed to be about 30 feet in thickness, as, although not exposed for that distance, the surface was covered with particles of the ore. Simple quarrying is here all that is necessary to obtain the metal. Close by, within about 150 feet, the band of cherty limestone, about 200 feet in thickness, likewise was found lying conformably with the iron beds. This hill is about 200 feet in height, and within a mile of a navigable canal leading to the river Yangtse; some specimens of the ore here were highly magnetic. Though I did not succeed in finding at this locality the coal-bed spoken of above, I have little doubt of its existence. The other locality is within two miles of a tile- and pottery-village called Paokiang-yau, itself about three miles from Kaotsêh-chên, a village situated on the main road to Nanking, with which, as well as Chinkiang, it has likewise water communication. Here also the ore is accompanied by limestone; but, owing to the intrusion of a large mass of porphyry, both iron and limestone are metamorphosed, the former into magnetic ore, the latter into white crystalline marble, much used by the natives for the manufacture of whiting.

"I also noticed beds of iron ore at the foot of the Chung-shan, within three miles of the Taiping gate of Nanking; they were visible here at the head of a small valley which cut into the rocks underlying the Chung-shan series. My specimens collected here, however, were by no means equal to the others; but, owing to their position, a good section could not be obtained of the beds."

In the same series in the Suichang district, and, indeed, all along the south bank of the Yangtse where this rock is exposed, a deposit of coal occurs. It seems to be a semianthracite mixed with a considerable amount of argillaceous impurities; the structure is somewhat lenticular, readily breaking into conchoidal lumps with smooth bright surfaces. In no locality have I found more than a single seam averaging some 3 feet in thickness. Though of inferior quality, from its frequent outcrops (owing to the convolutions of the strata) it has been worked to some extent by the Chinese—these mines, however, being generally little more than surface workings, a shaft some 3 feet high and perhaps $2\frac{1}{2}$ feet wide being driven into the hill-side at an angle of about 45° with the horizon till the coal is struck. No system of drainage is attempted, the holes being generally situated at a sufficient elevation to admit of a natural exit for the water. The seams being for the most part vertical or highly inclined, no galleries are driven, the coal being only removed from the immediate neighbourhood of the shaft, up which it is carried by naked boys in wicker sleighs.

For most purposes this coal is unsuitable; a similar kind brought down from Hunan, however, is burnt to a considerable extent by the steamers trading between Hankow and Shanghai; it throws out a considerable heat, but, from the amount of extraneous matter contained in it, is apt to run to slag and choke the furnaces. The seams seldom crop out at any considerable altitude, so as to allow of free drainage if worked deeply, while the quality and thickness of the seam is not sufficient to render heavy machinery profitable. As the coal occurs in immediate proximity to iron, it may possibly be found useful for smelting at some future period. I have found only one fossil in connexion with this bed in anything like a good state of preservation—the leaves are set alternately, and have a well-marked midrib with parallel striæ, which seem likewise to be continued in the stems. There is, however, a possibility of this plant belonging to the same bed as those before noticed (p. 121), the exposure of the rocks not being sufficiently continuous.

Taking the whole Tungting system there is a striking resemblance between it and the Devonian and Subcarboniferous rocks of the south of Ireland—the same succession of grits and shales at the bottom, and a similar development of limestone above; while the type of the few fossils found seems likewise to approach that of the Lower Carboniferous rocks of Europe.

With No. 8, described in the Table as the Upper Limestone, the system, so far as my knowledge extends, ceases; I have in no locality been able to trace the ascending sequence. On the Yangtse, however, immediately to the west of the Suichang district described above, a series of coarse sandstones and quartzose grits interspersed with brownish shales succeeds, though apparently not conformably. Near the village of Hwangshihkang, situated on the river some seventy miles below Hankow, these rocks are largely developed; the prevailing dip is E. or W., or nearly at right angles with the older rocks, which are found in bold hills overhanging the river a few miles lower down, and which form a continuation of those at Suichang. This series contains in the district at least one coal-seam, which is worked at a place called Yishan, some six miles distant from the river; the coal is slightly bituminous, but soft and friable, and does not appear to occur in quantity; the seam is said to be about 3 feet thick, and dips towards the west at a slight angle. The coal rests on a bed of whitish clay containing the remains of roots, and is capped with a black shale in which occur plentifully remains of *Sigillariæ* (apparently *S. reniformis*), as well as leaves resembling in their striæ those before spoken of. The series seems to be overlain at no great distance by the succeeding formations; but a hasty visit some four years ago did not give me time to note the sequence satisfactorily. At Hingkwoh, situated in the same district, but more to the east, a bed of similar coal is said to occur; the district is surrounded by the earlier rocks of Suichang.

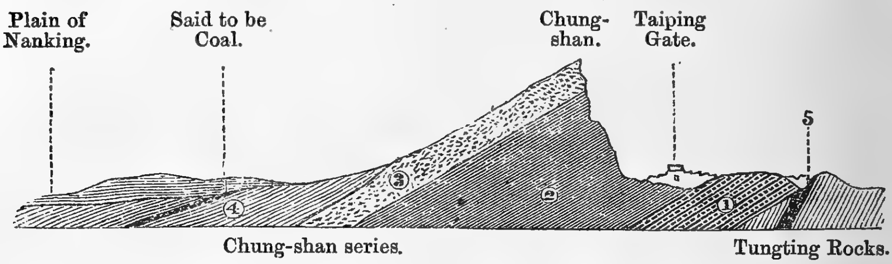
At Nanking, however, the lower Tungting beds are succeeded by a very important series of newer rocks, which, as occurring preeminently in the Chung-shan outside the north-east angle of the city, may conveniently be named the Chung-shan series. Following the system adopted in the nomenclature of the lower beds, they may be subdivided as follows:—

4.	Chung-shan series.	Grits and coarse yellow sandstones containing beds of coal............	unknown.
3.		Quartzose conglomerate	About 100 feet.
2.		Red flagstones	„ 1800 „
1.		Coarse red grits and sandstones.. ...	„ 500 „

I do not know the lateral extension of the series, which assumes some importance in this district; it seems to extend to some distance to the south and west of Nanking, and to be repeated to the north of the river Yangtse, where, however, as yet, I have had no opportunity of becoming acquainted with the rock-masses. I am disposed, however, to look upon it as the representative of the newer coal-beds of North China, at least until further investigation has proved their dissimilarity. South of Nanking, in a range of detached hills between that city and Taiping-fu, rising to some 1000 feet over the plain, another series of yellow quartzose grits and conglomerate occurs; the conglomerate is remarkable from containing fragments of the Tungting limestones, as well as pebbles of quartz rock, which can only be referred to that formation: this I am disposed provisionally to look upon as the summit of the series; but as I have never met with a similar formation in other localities, this is of the less importance to our present purpose.

The lower beds of the Chung-shan series offer few peculiarities. They lie unconformably over the edges of the Tungting rocks, as may be readily observed on the road leading from the Taiping-mên at Nanking, and contain occasional fragments of the older rocks imbedded in them. The lowermost rocks are very irregularly deposited, but are followed by a system of fine-grained dark red sandstones (No. 2), which attain a considerable thickness. The series within the immediate district of Nanking (fig. 5) ranges from the neighbourhood of the village of Tungliu, twelve miles outside the Taiping gate, to the Chung-shan, where it attains a height of about 1700 feet, and thence descends again, forming a range of low hills running through the city from the Taiping-mên, under the Kulow, and ending in some low hills outside the west wall, near the old Tsingliang-mên. The dip is towards the S.E., at an angle of about 30° in the Chung-shan, but gradually decreasing at each extremity. The bed No. 3, as being composed of harder and more compact materials than the others, forms the summits of the hills, and in the Chung-shan presents a steep escarpment to the N.W., on the S.E. face gradually dipping under the later beds. Towards the east the upper beds (No. 4) run up into a small valley formed in the earlier rocks, where, close by a village called Pah-hwei-miau (see section, fig. 3, p. 124), they gradually thin out. Here some shafts have been sunk by the Chinese, and a small portion of coal extracted from a seam which approaches the surface. Coal-mines are also said to have been worked on the upper outcrop of the beds on the S.E. face of the Chung-shan, though when going over the country (previously, however, to receiving the information) I did not notice them. This upper outcrop is covered to a slight depth with the superficial deposits, which mask the sequence.

Fig. 5.—*Section of Chung-shan near Nanking.*
(Scale 4 miles to 1 inch.)



1. Red Grits. 2. Dark-red Flagstones. 3. Quartzose Conglomerate. 4. Coal-bearing Rocks, overlain by later formations. 5. Hæmatite-bed.

From the Chung-shan, easterly and southerly, these rocks dip under the more modern deposits of the plain of Nanking, and appear in parts to have undergone considerable denudation. At Pah-hwei-miau I searched for some time for the outcrop of the coal-beds; but, owing to the manner in which the strata died out against the older rocks, it was not visible. The mines have been closed for some years, although partially worked during the siege of Nanking. Water and foul air have accumulated in the pits so as to render descent impossible, while most of the old inhabitants have lost their lives during the rebellion, or been dispersed over the country. From these circumstances, I have been unable to obtain a definite idea of the value of this coal-field, or of how many workable seams exist. Of the seam worked by the Chinese I could learn but little: some said it was 3 feet thick, some 8; but none of the actual miners could be found, they having all left the country. I was able to obtain a few specimens of the coal, which was of a bituminous slightly caking variety, and seemed, making allowance for seven years' exposure, to be of fair quality; the fracture was bright and clean; and though the specific gravity was rather low, it was reported to me by the master of one of the Imperial steamers which regularly coaled from these mines during the siege of Nanking, that they had found it of most satisfactory quality. The covering rocks are coarse siliceous sandstones, readily disintegrated and easily removed, from the want of tenacity in the cementing substance. The surface acquires, on exposure, a deep black colour, though the general tint of the beds is a faint yellow. Associated with the coal seemed to be siliceous shales, containing small bullet-shaped nodules of iron pyrites and the remains of a few ill-preserved stems, the character of which was unrecognizable.

With the exception of some Annelid-burrows and tracks in No. 2 and the ill-preserved stems in No. 4, I have procured no fossils to aid in judging of the geological age of these beds; should they, however, represent those at Hwangshihkang (p. 128) they should apparently be referred to the latter portion of the Carboniferous age. In the north of China a similar series of beds seems to occur (though here I am not speaking from personal experience, nor do my authorities aid me much by their descriptions); both anthracite and bituminous coal are found apparently in the same district, the anthracite probably representing the coal-bed in the Tung-ting system, the bituminous the Chung-shan coal. Remains of Cycads have been found in these northern deposits, of the fossils from which Père David, at Peking, has made a large collection; and from this the American geologists who examined Mr. Pumpelly's specimens have concluded that the Chinese coal-fields are of Triassic age. Should the fossil mentioned (p. 128) be a Cycad, as seems not unlikely, this would be an instance of that family of plants being found with an undoubtedly primæval flora—a fact the more interesting as Cycads to the present day flourish in the adjoining country of Japan.

In the province of Chehkiang, in the prefecture of Ningpo, the lower portion of the Tung-ting series is largely developed, quartzites highly metamorphosed and associated with granites and porphyries forming the prevailing rocks; agates and fluor spar are found in considerable quantities; while iron, in the shape of magnetic ore of considerable value, is in many places worked to a slight extent, being obtained in the shape of sand from the mountain-torrents. In the Chusan islands, within this prefecture, the coast chain of the northern provinces may be said to end; and in them, associated with granite, occur portions of these grits, similar in many respects in aspect to the same rocks in Hong Kong. Following the series inland, though the sequence cannot be so readily seen as in the central provinces, we seem to pass over the Tung-ting grits, and in the prefecture of Kinghwa and Hangchow to meet with limestone, which, along the valley of the Tsientang, the principal river of the province, is said to be associated with beds of coal. In the prefecture of Ningpo, near the town of Tszeki, at Ningkong-kiu, in the "Snowy valley," and at many other places there occurs, overlying unconformably the lower quartzites and shales, a very peculiar series of conglomerates, trappean grits, and flag-stones. The position is very similar to that of the Chung-shan series, and the dip in the neighbourhood of Ningpo, S.E. 5° to 15°, the same as at Nanking. The rocks seem to commence with a conglomerate formed from the wear and tear of the older rocks, and to be succeeded by a coarse trappean grit of a greenish colour; this grit is coarsely laminated, the cleavage-planes crossing those of bedding at high angles, and is used for coarse flag-stones. It often contains imbedded fragments of the older rocks, across which, irrespective of their structure, the superinduced cleavage runs. Succeeding these grits is a thick mass of fine-grained siliceous grits and flag-stones, often finely laminated and ripple-marked, and divided by vertical joints. This series is exceedingly well developed near the village of Ningkong-kiu, where the river, flowing along a valley formed by one of these jointage-planes, affords a good section on both sides. I have found no fossils of any sort in these rocks; they differ entirely in composition from the Chung-shan rocks, though, as they are identical in position, they may probably be referred to the same age.

In Hunan the coal series, which there, as in Kiangsu, occurs interstratified with limestones, is supposed by Mr. Bickmore to run up into Red Sandstone. In Kwangtung, in the department of Hwa, locally called Fayune, a small coal-field, apparently covered with Red Sandstone, likewise occurs. In the north of the same province, in the prefecture of Shao-chow, coal, said to be of inferior quality, is likewise worked. In the north-east of the province, in the prefecture of Chao-chow, on the borders of Fuhkien, there are likewise coal-mines. In Chehkiang, as above-stated, in the prefectures of Kinghwa and Küchow, coal-mines were worked until the disturbances consequent on the Taiping rebellion; they are now reported as closed, and the inhabitants left to rely on foreign importation or to use charcoal, the latter a fuel gradually becoming scarcer with the increased weakness of the government. In Kiangsi, in the prefecture of Kwangsiu, coal of good quality seems to be worked from vertical shafts, the only means of raising it, however, employed by the Chinese being a common wooden winch; the mines are ventilated by forcing down air through bamboo tubes. In the prefecture of Kanchow, in the same province, coal-mines also occur; in fact, as Kiangsi may be said to represent a basin of newer rocks surrounded by a rim of the older subcarboniferous series, coal will probably be found to occur in the greater portion of the province. I have had no opportunity of examining the position or quality of any of these coals.

In Hunan, however, the most important coal-field of South China has long been worked; it has also supplied large quantities of iron. According to Mr. Bickmore, the coal is interstratified with the limestone, representing, therefore, the older beds. What coal I have seen agrees in quality and structure with that from Suichang, described above. Hunan coal is an important article of traffic on the river Yangtse—the lower provinces, though containing themselves considerable quantities, being dependent on that province for their supplies, owing to the jealous conduct of the government. Coal which at the pit's mouth costs from 70 to 100 copper *cash* per *picul* (say 6*s*. to 7*s*. per ton) is sold at Nanking at 750 *cash* per *picul*, or over 50*s*. per ton; the difference in price is partly owing to the length of carriage, some 600 miles, but principally to the heavy exactions levied by the local mandarins.

The northern coal-fields of China are so important, cover such a vast area, and, as yet, have been so imperfectly explored that any more than an allusion to them on my part would be presumptuous. Suffice it, therefore, to say that enormous deposits are known to occur in Shantung, Chihli, Shansi, Shensi, and Kansu in China proper, as well as beyond the frontiers in Mongolia, Manchuria, and Shingking, where the coal-beds come down to the sea-coast.

Above the upper coal-fields in China there seems to occur a break, the next series in ascending order with which I am acquainted lying unconformably over them, generally dipping at small angles and seldom rising to any height over the plains. In the Nanking district it commences with a series of conglomerates, and passes up into a light red sandstone, not unlike the New Red of many parts of England. These finally give place to thick beds of coarse gravel and sand, the gravel generally composed of pebbles from the hardest portions of the siliceous grits of the Tungting series. At Nanking this series is well shown in the Yuhwatai and Tsingliang hills, the latter displaying the lowest beds, the other the summit. From Nanking the beds extend for considerable distances to the south and west, reappearing at various spots in Kiangsu, Anhwei, Kiangsi, and Hupeh. At Tatung on the Yangtse, at the foot of the Wild-Boar Hills, they come down to the river, forming a series of bold bluffs. At Hwangchow, in Hupeh, the upper gravels are exposed likewise in a bold escarpment, running almost under the walls of the city; near Hwangshihkang, again, they appear in a manner identical with that of their occurrence at Nanking, associated with dark lenticular argillaceous nodules and a few vegetable stems, which seem characteristic of the formation in the province of Hupeh, where it has a very considerable lateral extension. With the exception of these few imperfect stems, I have met with no fossils in the formation, which may be of late Secondary, or even of Tertiary date, passing, as it appears to do, into the succeeding clays. In Kwangtung, again, in the delta of the Canton river, red sandstones reappear, forming low hills in the valleys of the older mountain-ranges; they are conspicuous in Tiger Island, above the Bogue, at the Second-Bar Pagoda, at Tamchow, where they are extensively quarried, and in most of the low hills in the neighbourhood of Canton and Whampoa. They are harder and darker in colour than those at Nanking, but appear to occupy a similar position; like them, too, they are, so far as is known, unfossiliferous; nor do they appear to contain any mineral of economic importance.

These sandstones are succeeded by considerable deposits of clay, which play an important part in the geology of central China.

According to Chinese cosmogony the earth was at one time inhabited by tribes of dragons and wild beasts of huge size and savage nature. So great was the confusion which spread through the world, and so loud the din of their incessant combats, that Heaven, unwilling to stand by and see so fair a land given over to continual strife and bloodshed, at length interfered and swept away the whole creation, introducing instead the present more orderly assemblage of animated beings. Proofs of this are found in certain beds in the centre and west of China, where bones of elephants, of tigers, and of gigantic horses and stags are dug up in sufficient abundance to form a common article of commerce under the name of *Lung-kuh*, "dragons' bones," or *Lung-chi*, "dragons' teeth;" and as these ancient animals were endowed with greater strength and vigour than the new race, Chinese philosophy holds that their remains used medicinally will impart to their enervated successors some of these lost qualities. Hence these bones and teeth, burnt and ground to powder, are administered in many complaints, for which they are held to be specifics.

These bones and teeth seem to belong to a Pliocene fauna; they are, in some cases, beautifully preserved, showing the interior structure of the teeth perfectly, and seem to have been deposited in a bright red ferruginous clay with beds of sand and gravel. I have obtained specimens of the teeth of a species of elephant, probably *E. priscus*; of fragments of altered ivory, probably belonging to the same; of two species of horse, one with enormous curved teeth (*E. curvidens*? and *plicidens*?); of an animal seemingly intermediate between *Palæotherium* and *Rhinoceros*, but the teeth of which are much broken; of a tiger, a pig, deer, and some others, including a large deeply fluted tooth not unlike that of *Glyptodon*. Of the localities of these fossils I am not prepared to speak. The results of inquiries I have made seem to concur in pointing them out as common to most of the central and western provinces, and I am, from this reason, as well as others, inclined to connect them with the clay beds of the centre of China. In Ava, in the valley of the Irrawadi, and in India, on the slopes of the Sewalik hills, similar deposits have long been known to exist. Their mode of occurrence in China will probably be found to correspond.

Besides these teeth of apparently Pliocene age, I have met with a number of fragments of fossil ivory, apparently Mammoth tusks, in a completely different state of preservation, the gelatine and animal matter being simply removed and leaving merely the earthy matter behind. No substitution of other minerals has taken place, and the remains adhere strongly to the tongue. These tusks are known in the Chinese pharmacopœia by the name of *Lung-kuh*, "dragons' bones." They are broken into small fragments before being brought to market; but some specimens I have seen would seem to point to a tusk from 13 to 15 inches in diameter. I cannot speak of their locality. Some of the Chinese state that they come from Mongolia.

In China the superficial deposits may be divided into two great classes:—the modern alluvial deposits of the great rivers, and notably of the Hwangho and Yangtse, whose united delta stretches from the

Great Wall, N. lat. 40°, to the neighbourhood of Ningpo, N. lat. 30°, and includes considerable portions of the provinces of Chihli, Shantung, Kiangsu, and Chehkiang; and the more ancient clay-beds, which form most of the plains of the interior, though even here, from the peculiar formation of the mountain-chains, only occurring in a number of isolated basins, and overlain in portions by the more modern alluvial deposits.

In the valley of Yangtse these older clays divide themselves naturally from their composition into three classes: 1st, the laterite of Kiukiang and its neighbourhood, apparently reaching into Anhwei province; 2nd, the yellow clays of Anhwei; and 3rd, the soft calcareous deposits of Kiangsu, well developed in the neighbourhood of Chinkiang. The first seems to rest immediately on gravels, representing apparently those forming the summit of the red sandstone described above (p. 133), these gravels at the foot of the Lu-shan passing into a coarse till containing small boulder-like stones (fig. 2). To these succeed beds of fine sand interstratified with clay; and over all are found thick deposits of a bright red hard clay, containing numerous vermiform cavities, and apparently precisely similar to the laterite of Southern and Central India. This clay is sufficiently hard to form bold cliffs overhanging the river Yangtse, and is so little affected by the action of water as to form tails of quasi-boulders running out at several points into the river, and very dangerous to navigation.

The second class forms a series of bright reddish, yellow, and grey clays, and is probably only a local variation of the former, as it varies much in appearance in different localities, forming a series of brick and pottery clays, and probably comprehending the famous porcelain clays of Kiangsi; it occurs in portions of Kiangsu, in Anhwei, Kiangsi, and Hupeh, besides stretching, as there is every reason to believe, to the extreme south and west of China.

Both these clays are distinguished by the almost complete absence of lime in their composition, and both are to a considerable degree ferruginous. I can at present form no idea of their thickness; but they have undergone in parts very considerable denudation. In the fissures and channels formed in the older limestone rocks by the action of water during previous ages, and up to a height of some hundred feet above the plains, masses of a bright red clay of apparently similar composition constantly occur, though I have not been able to trace the clays themselves for any considerable height; unless towards the bottom, these clays are unstratified. To this formation I am disposed at present to refer the fossil bones and teeth spoken of above. In South India the laterite has, I believe, been usually referred to the Pliocene age, which would seem to harmonize with the mammalian fossils found in apparently similar deposits in China.

In lower Kiangsu, and notably in the neighbourhood of Chinkiang and Nanking, these older beds are succeeded, apparently unconformably, by a mass of eminently calcareous clays of a pale yellowish brown colour and extremely friable texture, so readily affected besides by water that most of the streams flowing down the sides of the hills take by preference subterranean courses. These beds are likewise unstratified, but seem to be roughly divisible into three layers, the upper and lower containing a considerable quantity of calcareous matter distributed through the mass, so as to effervesce violently with acids, while in the middle the lime and other soluble salts have, for the most part, segregated into long irregular nodules, curiously twisted and contorted, and most of them having their longer axis vertical. By means of this intermediate layer the beds may be noticed to dip at extremely small angles, and generally towards the south of east. Like the former, this series has suffered considerable denudation; but patches of it may be seen here and there upon the sides of the adjacent hills to a height of about 500 feet. In Shantung a similar clay seems to form the surface of the higher plains, specimens in my possession from that locality being precisely similar in appearance and structure. With this exception, I do not know of its occurrence elsewhere in China. I have met with no fossils of any sort in these clays, nor do I know of any which can with any reasonable probability be referred to them. Similar clays in India have, I believe, been referred to a Pleistocene date.

Of still later date, and at the present day proceeding in their formation, are the alluvial deposits of the great rivers, more especially the Hwangho and Yangtse. Within historical times the growth of their united delta has been so rapid, and the changes of the coast-line and the river-channels so numerous, that the ancient history of these regions seems almost incomprehensible till studied by the light of modern research. With the continual advance of the coast-line the level of the rivers in the interior seems to have been continually raised; and from this cause, in many localities in the interior of the country, alluvial deposits of modern date cover up the older clays. In the plains of Hupeh and Anhwei the Yangtse overflows annually, forming large lakes, sometimes fifteen or twenty miles in breadth. In Kiangsi, in the basin of the Poyang lake, and in Hunan in that of the Tungting, similar floods occur. But it is along the course of the Yellow River that the effects of the gradual elongation of the channel are most apparent; and in these districts, from the earliest dawn of history, we find the care of the embankments uppermost in the minds of Chinese statesmen. Tradition hands down the half-heroic Yu, the model of Chinese emperors, less as a politician or a successful general than as an engineer. The semifabulous Yu-kung, apparently a record more of his political arrangements than of his engineering labours, has, by the glosses of later commentators, been made to represent his struggles with and final victory over the two great rivers. The entire subject, however, is too wide and of too great importance to be taken up at the tail-end of a paper such as this. Count D'Escayrac de Lauture, in the 'Proceedings of the Société de Géographie' for 1862, and more recently Mr. Pumpelly, as I learn in 'Silliman's Journal,' have treated more or less fully of the changes of the Yellow River; while the Rev. J. Edkins, in the second volume of the 'Transactions of the North China Branch of the Royal Asiatic Society,' has published a memoir on those of the Yangtse. Much information, however, still remains to be gleaned.

Wherever the opportunity offered, I have made careful search for relics of glacial action in the south of China, but hitherto without success. In fact, the general appearance of the country forbids the hope of any such discovery, one of the most prominent features in the landscape, as mentioned above, being the needle-like and fantastic forms of those portions of the limestone rocks in the northern provinces which have escaped the solvent power of water. Of the appearance of the limestones in the central and eastern provinces the same may be said; they are everywhere pierced by holes produced by water action; the surface is cut up by fantastic projections; and where chert nodules occur, these uniformly jut out far beyond their former matrix. The Chinese are much skilled in making rockeries of fantastic shapes; but in these eroded limestone rocks they find not only the materials but the pattern ready to hand. Almost equally characteristic of the action of water is the denudation of the earlier grits. The mountain-sides are scored by deep ravines with sharp intervening crests, and present none of the rounded forms peculiar to glacial action. Except close to the flanks of the mountains, as near Kiukiang, I have never met with boulders; while the parallel striæ which are so conspicuous in the ice-worn rocks of Europe seem to be entirely absent. Whether in the higher mountain-ranges of the south and west remains of ancient glaciers are to be found, I am not in a position to state; in none visited by myself did I notice traces of their former existence.

Reverting, then, to the topics discussed in the foregoing pages, the following general conclusions may be arrived at.

First and most important seems to be the enormous development, both laterally and vertically, of the representatives in China of the sub-Carboniferous rocks of Europe.

Secondly, the enormous extent to which they had been altered, contorted, and upheaved, with the accompanying intrusion of repeated outbursts of igneous rocks, after the close of this period, and antecedent to the deposition of the newer coal-beds, classed, at the latest, as Triassic, and which upheaval must have left the main framework of the country almost in its present state.

And, thirdly, the comparatively small importance, south of the Yangtse, of the deposits of Secondary or Tertiary age. With the exception of a partial submergence during the deposition of the Pliocene clays, the face of southern China has probably retained, in great measure, a similar aspect since the upheaval of the later coal-beds—a time sufficiently long to have allowed the action of water on the limestones of the Tung-ting series to have slowly and gradually dissolved and carried away a series of rocks probably 6000 feet in thickness, and extending laterally over a considerable portion of the province of Kwang-tung, the gentle character of the erosion being sufficiently shown by the fantastic shapes of those portions which, probably owing to a difference in their chemical composition, induced by metamorphic changes during the age of elevation which marked the close of the Palæozoic age in China, have hitherto resisted the action of the great solvent.

Other facts of interest in connexion with the geology of the districts treated of are, the absence of glacial action south of the Yangtse, and the large deposits of rich iron-ore, together with considerable quantities of coal, in the central provinces, while the careful study of the Tertiary and modern beds may probably at some future period throw light on the vexed question of the antiquity of the human race.

Discussion.

The President remarked that if the South of China had been dry land since so early a period, the fauna might have been expected to resemble that of the Siwalik Hills. Among the teeth was the molar of a very small horse, presenting some of the characters of *Hippotherium* or *Hipparion*, which might *possibly* be of Miocene date.

Prof. T. Rupert Jones alluded to the general parallelism of the axial folds of the strata with the coast-line, and to the similar strike of the gold-bearing rocks in the Gulf of Petchele, and mentioned that Cycadaceous remains occurred in the coal of some parts of Germany as in China.

Mr. W. Boyd Dawkins remarked that one of the equine molars was the largest of the class he had seen. He agreed with the President as to the smaller molar. He was unable, from the specimens, to determine whether they were Miocene or Pliocene. He mentioned the discovery in the laterite of India of a portion of a human femur of most remarkably slender make.

January 13, 1869.

William Groome, Esq., B.A., of St. John's College, Cambridge, was elected a Fellow; and Dr. J. F. Brandt, of St. Petersburg, Prof. A. E. Nordenskiöld, of Stockholm, and Prof. F. Zirkel, of Kiel, were elected Foreign Correspondents of the Society.

The following communications were read:—

1. *On* Hyperodapedon. By T. H. Huxley, F.R.S., Pres. Geol. Soc.

A little more than ten years ago, namely, on the 15th December 1858, Sir R. Murchison read a paper "On the Sandstones of Elgin" before this Society. It was followed by an essay of my own "On the *Stagonolepis Robertsonii*," an animal so named by Prof. Agassiz in his 'Poissons fossiles du Vieux Grès Rouge' from some impressions of its dermal covering which had been discovered in the Elgin sandstones. In the latter paper, and in notes added to both papers, before their publication in the middle of the following year, the fact that *Stagonolepis* was a reptile closely allied to the Mesozoic *Croco-*

dilia, though distinct from any known form of that age, was for the first time asserted, and, indeed, I may say, demonstrated, the remains placed in my hands enabling me to put the fact beyond doubt. At the same time I mentioned the existence in the same beds of "a Saurian reptile about 6 feet long, remarkable for the flattened or slightly concave articular surfaces of the centra of its vertebræ, and for its well-developed costal system and fore and hind limbs, but more particularly characterized by its numerous series of subcylindrical palatal teeth." I named this new reptile *Hyperodapedon Gordoni*, in honour of its discoverer, the Rev. Dr. Gordon, to whose exertions in the Elgin country geology owes so much: and I stated that "its marked affinity with certain Triassic reptiles, when taken together with the resemblance of *Stagonolepis* to Mesozoic *Crocodilia*, lead one to require the strongest stratigraphical proof before admitting the Palæozoic age of the beds in which it occurs."

Sir R. I. Murchison admitted that his belief in the Devonian age of the Elgin sandstones was "somewhat shaken" by the discovery of the nature and affinities of these reptilian remains.

In the ten years which have elapsed since the papers to which I have referred were read before the Society, the age of the reptiliferous sandstones of Elgin has been repeatedly discussed by some of the most eminent of English geologists, with the general result that while one half of the disputants produced excellent reasons for believing them to be of Mesozoic date, the other half adduced no less weighty arguments in favour of their Palæozoic age. And it is a curious circumstance that in this Geological Siege of Troy, Priam has been fighting the battle of the Greeks, and Nestor that of the Trojans,—Sir R. Murchison, whose general geological views would naturally incline him to assign a later date to these Elgin reptiles, having been the sturdiest champion of their Devonian age; while Sir Charles Lyell, who ought to rejoice if they could be made out Palæozoic, has as strongly fought for their belonging to the Trias. Without meaning to compare myself to Achilles, I may say that "under these circumstances" I thought it best to retire to my tents and take no part in the fray until my palæontological armoury should yield more efficient weapons. And as my excellent friend Dr. Gordon supplied me from time to time with new specimens, I lived in hope that one day or other I should be able to make an effective sally.

No such opportunity presented itself, however, until the year 1867, when a number of important facts came to light in singular coincidence, and, as I conceive, rendered the proper discussion of the question and the drawing of satisfactory conclusions somewhat easier than before.

I may premise that the original specimen of *Hyperodapedon* is in a very bad condition, the substance of the bones and teeth being extremely friable and decayed. It is nevertheless sufficiently clear that the roof of the mouth is provided with several parallel rows of teeth, that the edge of the ramus of the lower jaw is also beset with a series of close-set or even confluent teeth, and that the mandibular teeth bite between the inner and outer series of the palato-maxillary teeth. The surfaces of the teeth, however, are not sufficiently preserved to enable one to make sure of the manner in which the teeth wear.

For a number of years I have been acquainted with two specimens from the quarry opened in a Triassic sandstone at Coton End, near Warwick—the one belonging to the Warwick Museum, and the other to the Rev. P. B. Brodie, F.G.S. Each of these is an elongated jaw-like bone, in which are set parallel rows of conical teeth; and I have often compared them with the palate of *Hyperodapedon*, but without being able to satisfy myself that I was entitled to draw any positive conclusions from their resemblance.

In the winter of 1866, however, the Rev. Dr. Gordon sent me several specimens, among which one (belonging to Mr. Grant, of Lossiemouth), though a very much mutilated fragment of a skull, presented part of the characteristic dentigerous bones of the palato-maxillary apparatus of *Hyperodapedon*; and my attention was, at once, forcibly drawn to the fact that the opposed faces of two of the rows of the teeth were worn down by attrition against other teeth. These two rows of teeth were placed on opposite sides of a deep longitudinal groove; and the planes of the worn faces converged to the bottom of this groove.

On looking at the original specimen, it became clear that this groove corresponded with the depression into which the oral edge of the mandible is received when the mouth is shut. The opposed faces of the palato-maxillary teeth had been worn flat by attrition against the opposite sides of the mandibular teeth, which work between them as a knife-blade shuts into its handle; and it followed that the dentary margin of the mandible must be worn to an edge adapted to fit into the groove. So far as I know, no other fossil reptile possesses any such peculiarities; and thus this interesting fragment presented me with new means of distinguishing the teeth and jaws of *Hyperodapedon* from those of other Reptilia.

Some time after I had become acquainted with Mr. Grant's new specimen, Mr. Lloyd, F.G.S., was good enough to call upon me for the purpose of showing me some specimens from the Coton-End quarry before mentioned, which had for many years been in the possession of his father, Dr. Lloyd, long well known for his attention to the geology of Warwickshire. Among these were two bones beset with teeth of the same character as those which I have already mentioned from the same locality, but far more perfect, and presenting rows of teeth not only quite like those of *Hyperodapedon* in form and arrangement, but worn in a precisely similar way; in fact, when Mr. Lloyd's specimens were placed side by side with Mr. Grant's, there was no resisting the conclusion that they proceeded from animals of one and the same genus, if not species.

I at once communicated these interesting facts to Sir Roderick Murchison, who refers to them in the following terms:—

"To such fossil evidence as this the field geologist must bow; and instead, therefore, of any longer connecting these reptiliferous sandstones of Elgin and Ross with the Old Red Sandstones beneath them, I willingly adopt the view established by such fossil evidence, and consider that these overlying sandstones and limestones are of Upper Triassic age."

Shortly after these new lights upon the structure and stratigraphical position of *Hyperodapedon* had appeared, the able Director of the Geological Survey of India, Professor Oldham, who happened to be in England, drew my attention to some specimens obtained from Maledi, in Central India, and presented to this Society in 1860 by the Rev. Mr. Hislop. Among these were fragments of large jaws with teeth, which presented all the characters of *Hyperodapedon*; and during the past autumn I received from Dr. Oldham a considerable number of similar remains, associated with those of Labyrinthodonts and Crocodilian reptiles. The peculiar interest of this discovery arises not only from the sudden, enormous extension of the distributional area of *Hyperodapedon*, but still more from the circumstance that Dicynodonts have been found in the same Indian strata, and, thus, that we get a step nearer to the determination of the age of the remarkable reptiliferous formations of Southern Africa, the Triassic or Permian age of which was already highly probable.

The last fact which needs to be mentioned in this history of the gradually growing importance of the genus *Hyperodapedon* is the highly interesting and important collateral evidence as to its age obtained by Mr. Whitaker, who will presently give you an account of the precise position in the Trias of Devonshire in which a specimen of the jaw of *Hyperodapedon*, which he brought to me a few weeks ago, was obtained.

I now proceed to describe the most important remains of *Hyperodapedon* which have come into my hands; and I shall speak first of the specimen on which the genus was founded, which is the property of the Elgin Museum, and was sent to me in 1858.

The remains of this specimen are exhibited by the opposed faces of broken blocks of sandstone, some of which have been separated by splitting along the plane in which the fossil lay. On one of these blocks are the indications of seventeen vertebræ in a continuous series, though slightly disturbed from their normal position here and there. The bodies of all these vertebræ have about the same length, viz. 0·9 in. or 0·95 in. They are so much constricted in the middle as to be almost hourglass-shaped, and their terminal articular surfaces are slightly concave. In most of the vertebræ the neural arches and spines are shown indistinctly, or not at all; but the sixth in order from the anterior end of the series is tolerably complete, and exhibits a broad and not very high spine, the summit of which is somewhat narrower than the base. This passes into the arch of the vertebra, which exhibits well-developed articular processes. The total height of the vertebra, from the lower edge of the posterior articular surface to the summit of the spine, is 1·85 in., that of the posterior articular surface of the centrum being 0·7 in.

The fourteenth vertebra of the series, from its general character and relations to the pelvis, is, without doubt, the principal sacral vertebra. The impression which it has left appears to me to have been formed by the outer face of the right sacral rib. Certainly not more than one of the three succeeding vertebræ, the two hindermost of which are represented by little more than casts of their neural canals and of the region thereabouts, can have been united with the principal sacral vertebra to form the sacrum.

On clearing away the friable remains of the original bone from the hard sandstone matrix, the latter presents casts of the external surface and of the neural canal of each vertebra, which, in some cases, are very perfect. These casts show no sign whatever of the deep pits which would correspond with well-developed transverse processes; but there is a depression at the anterior part of each body of a vertebra answering to what appears to have been a low tubercle for the attachment of a rib, as in existing lizards.

In correspondence with this structure of the vertebræ, the remains of a number of ribs, which have been laid bare by chiselling away portions of the matrix, show no trace of a division into capitulum and tuberculum at their vertebral ends. The longest of them is 4 inches in length. Like the rib of a *Monitor*, its vertebral end is somewhat expanded; and it is so curved as to be, at first, a little concave towards the dorsal aspect; in the rest of its extent it is convex in that direction.

I see no remains of true sternal ribs; but there are numerous faint transverse linear impressions of a system of dermal ossifications, which I conceive, answers to the so-called "abdominal ribs" of a Crocodile, or to the corresponding structures in *Sphenodon*. These, however, are better shown in another slab.

To the anterior extremity of the block of sandstone which contains these vertebræ (and which I shall call No. 1) fits another, which bears the anterior cervico-dorsal vertebræ and the skull. The latter is bent round so that its axis is nearly at right angles with that of the body.

None of these anterior cervico-dorsal vertebræ can be clearly made out; but they cannot have been numerous, and I doubt whether there were altogether more than twenty, or twenty-two, presacral vertebræ.

The skull had a length, when complete, of not less than 7 inches. It is about 5 inches broad posteriorly, but anteriorly narrows to a deflexed and comparatively slender snout, the diameter of which is not more than 1 inch. It is so disposed as to turn its ventral aspect to the eye. The left ramus of the lower jaw is in place, though much mutilated. The right ramus is broken away, and shows the oral surface of the palate and maxilla, with the obscure remains of several obtusely conical teeth.

On the left side, a good deal of the dentary edge of the left ramus of the mandible is preserved, and it is seen to be shut against the upper jaw, passing on the inner side of a series of mutilated teeth, which are fixed on the maxilla. The end of the snout presents a very remarkable structure. The anterior portion of the edge of each maxilla curves upwards, so as to leave a deep notch between itself and the downwardly curved, beak-like anterior termination of the snout, which appears to be formed altogether by the præmaxillæ. Into this notch the surface of the matrix indicates that curved upward processes of the mandibular rami fitted. Whether these processes, and those of the præmaxillæ which projected between them over the mandibular symphysis, ended in teeth, or not, cannot be determined, as the extremities of the premaxillary processes are broken away, and the mandibular processes are represented only by impressions. But it is very likely that such was the case, if we may judge by the analogy of some existing lizards (such as *Uromastix spinipes*), which present a very similar arrangement of the extremities of the jaws. The two præmaxillæ, however, are confluent in this lizard, while they are distinct from one another in *Hyperodapedon*.

From the dentary margin the outer surface of each maxilla inclines rapidly outwards, so that, even making allowance for partial artificial depression, the measurement from the outer margin of one orbit to the other is nearly double that between the dentary margins of opposite sides. This conformation of the upper jaw also obtains, though to a less extent, in *Uromastix*.

The orbit was large; but its form cannot be accurately determined, almost the whole of the roof of the skull being absent. There is a cast of a strong supratemporal zygomatic arch, formed in part by a prolongation backward of the jugal, and in part by a forward extension of the squamosal, as in *Uromastix*. Clear indications of a strong quadrate bone and of a pterygoid are also visible; and the remains of a long slender left cornu of the hyoidean apparatus lies parallel with the left ramus of the mandible, on the ventral face of the skull. No remains of any infratemporal zygomatic arch, such as is found in *Chelonia*, *Crocodilia*, and *Aves*, are visible; but the existence of such a structure is very probable from the analogy of *Rhynchosaurus*.

The remains of two broad plates of bone, not less than $3\frac{1}{2}$ inches in length, with concavo-convex surfaces and a curved free edge, which lie near the anterior end of block No. 1, most likely represent the coracoids. A large impression of about the same length, which must have been formed by a bone which was thin at both edges, thin and expanded at one end, and thick, with an excavated terminal surface, at the other, lies near one of the coracoids; and I take it to have been made by a scapula. What I suppose to be a cast of the corresponding bone of the other side lies upon block No. 2; and there are sundry scattered imperfect impressions of limb-bones, indicating a fore leg of no great size. The right pubis and ischium have left very distinct impressions of their dorsal surfaces at the hinder end of block No. 1. In general form these bones resemble the corresponding bones in existing lizards; and the pubis has a great prepubic process, as in the latter. But the pubis and ischium of the same side seem to have united on the inner as well as on the outer side of the obturator foramen, which appears to have been proportionally much smaller than in existing Lacertilia.

The pubis and ischium occupy a space equal in length to four vertebræ, which is a proportion very similar to that which obtains in existing Lacertilia.

A distinct impression of the right femur is left almost in its natural position. It is a nearly straight and very strong bone, which is 4·7 in. long, or equal to more than five vertebræ in length. The femur has a similar proportional size in *Monitor* and *Iguana*. Impressions of the proximal ends of the tibia and fibula are visible, in such relation to the femur as shows them to have undergone very little disturbance.

No certain indication of the character of the feet is discernible.

The general arrangement of the teeth has been described. The downwardly convex dentigerous edge of the maxilla is 2·75 in. long, and appears to have carried about eighteen (or perhaps more) teeth, of a conical form and very closely set. The outer surface of the maxilla, from the dentigerous edge to the lower boundary of the orbit is fully an inch high, and is excavated and inclined outwards with a very peculiar curvature.

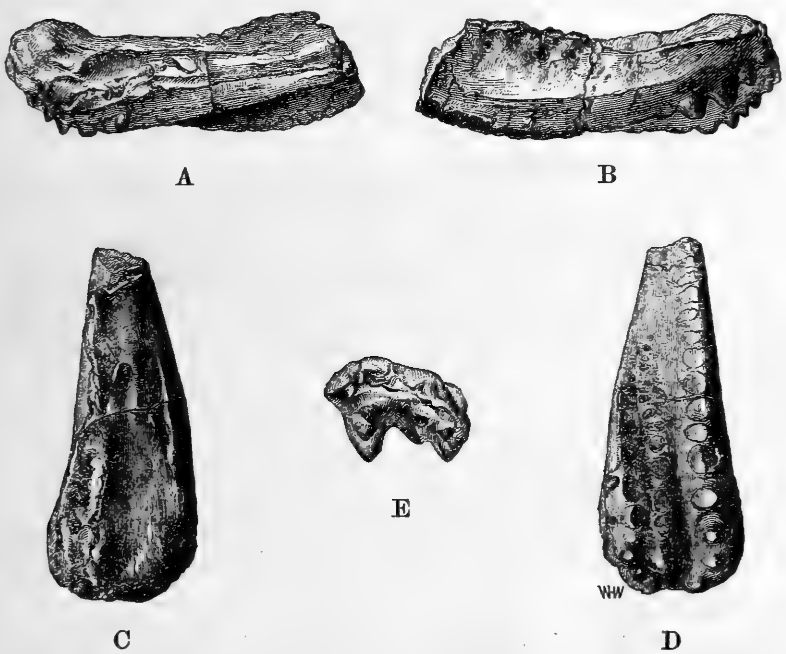
The dentigerous edges of the opposite maxillæ converge towards one another at an angle of about 45°, and then become parallel as the snout narrows to its termination.

No suture can be distinguished upon the roof of the mouth, between the maxillæ and the palatine bones, though the boundary line between the two is probably indicated by the groove into which the dentigerous edge of the mandible bites. The roof of the palate is therefore formed by a broad plate of bone, which may be called palato-maxillary, as it is constituted by the conjoined maxillary and palatine. Anteriorly this plate has a width of not more than 0·35 in. internal to the groove, but it widens posteriorly to 0·7 in. Its inner edge is convex towards the middle line, roughly following the course of the dentigerous edge. For their anterior halves the two edges of the palato-maxillary bones seem to be separated by only a small interval; but posteriorly they diverge widely; whether the interspace was occupied by the pterygoids, or not, cannot be ascertained.

The palato-maxillary plate on the inner side of the groove bears three (or perhaps four) longitudinal series of conical teeth, the largest of which are about 0·1 in. in diameter at the base. The posterior edge of the palato-maxillary is abruptly truncated, smooth, rounded, and slightly concave backwards.

It is upon this part of the organization of *Hyperodapedon* that Dr. Lloyd's specimens throw such important light. One of them, which is smaller and more perfect than the other (fig. 1, A, B, C, D, E), exhibits nearly the whole of the characteristically convex dentigerous margin, and excavated and outwardly inclined outer face, of the palato-maxillary of *Hyperodapedon*. Its posterior margin is smooth and rounded below, exhibiting the natural termination of this part of the bone. The inner surface is also quite smooth, and could not have united suturally with any other bone. The anterior end of the bone is broken off transversely; but probably very little of it is lost. As it is, it measures 1·5 in. in length; and the palatine surface has a width of 0·25 in. in front and 0·55 in. behind. The section of the bone is trihedral, the outer face of the trihedron being somewhat concave, the inner convex from above downwards; the anterior half of the upper edge is thin and broken; the posterior half is a comparatively broad, longitudinally grooved, narrow surface. Along the bottom of the groove lie three apertures, which are probably vascular foramina; and other such foramina lie on the inside and on the outside of the ridge into which the anterior half rises. One of the foramina on the inside is the commencement of a canal which traverses the base of the ridge longitudinally.

Fig. 1.—*Left palato-maxillary of* Hyperodapedon.



A. From the inside. B. From the outside. C. From above.
D. From below. E. From behind.

The posterior half of the oral surface of the bone presents two faces, which are inclined towards one another at an obtuse angle; the wide valley which they include ends abruptly in a sharply cut narrow groove. On the outside of this groove lies a single row of fifteen teeth, anchylosed with the edge of the outer wall of the valley. The anterior eleven of these are worn down to a level with the bony substance of the jaw; the twelfth and thirteenth have their points ground away, while the fourteenth and fifteenth are entire and sharply pointed.

The inner wall of the valley presents two parallel series of teeth —one on the middle, and one on the extreme inner edge. Traces of fourteen or fifteen teeth can be discovered in each series. Those of the middle series are, all but the very hindmost, worn down to the surface of the bone, while of the inner series the four hindmost teeth are but little affected by wear. The teeth of the outer series are larger than those of the inner, the base of the largest being 0·15 in. in diameter; the middle teeth in each series are the largest, the anterior and posterior diminishing in size.

The inner two series of teeth cannot be traced as far forward as the outer, the inner wall of the anterior half-inch of this valley being so thoroughly ground down that it is converted nearly into a plain. It is a curious circumstance that at the posterior part of the inner surface the apices of four teeth appear, as if they were about to protrude on this face. It is quite clear that this remarkable wearing down of the palato-maxillary teeth can only be explained by their attrition against the teeth of the mandible; and the sharpness of the groove in the posterior half of the palatal surface clearly shows that these mandibular teeth were themselves sharpened to a sort of knife-edge.

Dr. Lloyd's second specimen is a fragment of a larger palato-maxillary bone of the same (left) side. It is, however, smaller relatively to the original size of the bone, as some of the anterior portion is broken away, and the posterior edge, though nearly preserved, is somewhat imperfect. The transverse diameter of the nearly entire posterior end is 0·8 in.; so that this bone is about half as large again as the foregoing, and belonged to an animal probably not more than half as large as the Elgin specimen.

In this specimen the outer series of teeth is double posteriorly, two large conical teeth making their appearance on the outer side of the four which remain tolerably unworn. As before, there are two rows on the inner side of the groove; and anteriorly all the series of teeth are worn down to one flat surface with the bone which holds them.

Mr. Whitaker's specimen *, from Devonshire, is a right palato-maxillary bone of a *Hyperodapedon* of small size, probably less than that to which Dr. Lloyd's smaller specimen belonged. It is in an imperfect condition, but shows part of a single outer series of teeth, and of two inner series, both completely worn down. The apices of four or five teeth project in two rows upon the posterior half of the inner face of this specimen.

I propose to give a full account of the Indian specimens elsewhere. At present I merely wish to observe that, for the most part, they belong to animals of a larger size than the Elgin specimen, but that I have not yet discovered any grounds for regarding them as specifically distinct. In the series sent by Dr. Oldham, there is a fragment of a ramus of a mandible which shows the scissor-edge character of the dentary margin extremely well.

* I am indebted to my friends the Rev. P. B. Brodie and Mr. Kershaw for drawing my attention to some additional examples of the Warwickshire *Hyperodapedon*. Two of them are fragmentary palato-maxillary bones. The third has very much the appearance of two crushed palato-maxillary bones, with one ramus of the mandible of a small specimen; but I have not been able to work it out fully.

With respect to the affinities of *Hyperodapedon*, there can be no doubt that it is very closely allied to the genus *Rhynchosaurus*, established by Prof. Owen upon a fossil skeleton from the Trias of Shropshire. But *Rhynchosaurus* has shown no trace of teeth in either upper or under jaw, and seems to differ from *Hyperodapedon* as *Oudenodon* does from *Dicynodon*. There is a certain analogy with another Triassic genus, *Placodus*, in the dentigerous roof of the palate of *Hyperodapedon*; but too little is known of the rest of the organization of *Placodus* to test the value of this analogy.

I do not find grounds for assuming any special affinity between *Hyperodapedon* and *Telerpeton*; nor has *Hyperodapedon* anything to do with the Thecodonts, Crocodilian or otherwise, which abound in the Trias.

But it is a very remarkable circumstance that it is nearly allied to an anomalous lizard, *Sphenodon* (*Hatteria*), which still lives in New Zealand. Professor Owen first directed attention to some similarities in the construction of the skull between *Sphenodon* (under the name of *Rhynchocephalus*) and *Rhynchosaurus*. A short time since, however, the New-Zealand lizard furnished to Dr. Günther, F.R.S., the subject for an excellent memoir now published in the 'Philosophical Transactions,' in which the many anatomical peculiarities of this singular saurian were first indicated; and on perusing this memoir, I was at once struck with the resemblance in the arrangement and wear of the teeth, as described by Dr. Günther in *Sphenodon*, to that which I had become acquainted with in the fossil lizard.

I have since had the opportunity, by Dr. Günther's kindness, of inspecting his osteological and other preparations, and I have satisfied myself that *Sphenodon* is the nearest ally to *Hyperodapedon* of all recent or fossil reptilia, except *Rhynchosaurus*.

Both *Sphenodon* and *Hyperodapedon* have amphicœlous vertebræ (those of the ancient reptile being far less fish-like than those of the modern one, be it noted); both have beak-like præmaxillæ, not anchylosed together; both have the inferior zygoma complete; both have similarly formed lower jaws; in each, a single row of teeth in the mandible bites between two rows of teeth fixed to a plate which is formed by a union of the maxilla with the palatine bone—a structure which is quite anomalous among Lacertians; and, finally, in both, these teeth wear down to the bone of the jaw by the effect of masticatory attrition.

I now proceed to offer to the notice of the Society a few general considerations which arise out of the facts just detailed.

With respect to the habits of life of *Hyperodapedon*, I see no reason to doubt that it may have been a purely terrestrial animal—though it is a very hard matter, from the structure of a Lacertian, to say whether it is entirely terrestrial or largely aquatic. Consider, for example, how nearly the aquatic and terrestrial *Varani* resemble one another, and how slight is the difference between that species of *Amblyrhynchus* in the Galapagos Islands which cannot be driven into the water, and that which takes to the sea habitually. All that can be said is that the Lacertilia are so predominantly terrestrial a group, that a member of the group is to be presumed terrestrial, or at any rate fluviatile, unless evidence appears to the contrary. True there is no evidence to the contrary in the case of *Hyperodapedon*; but, on the other hand, all that we know of its contemporaries and compatriots, *Stagonolepis* and *Telerpeton*, leads to the belief that they were terrestrial or semiaquatic. *Telerpeton*, I have little doubt, was altogether terrestrial. *Sphenodon*, the existing ally of *Hyperodapedon*, is a sluggish animal, which lives, in part, at any rate, on insects and small birds, and is said to frequent burrows in the sand near the sea-shore. The fact that no marine remains have ever been found in the deposits which contain *Hyperodapedon*-remains is negative evidence which leads in the same direction; and it is strongly confirmed by the association of Labyrinthodonts with *Hyperodapedon* in Warwickshire and in India,—Labyrinthodonts, like all other amphibia, being confined to the land and fresh water.

The question of the terrestrial habit of *Hyperodapedon* assumes a great importance when the wide distribution of the genus is taken into consideration. It has now been discovered in the North of Scotland, in the centre of England, and in Central India; and if it were, as I doubt not it was, a terrestrial or semiterrestrial animal, that alone indicates the existence of a very extended mass of dry land in the Northern hemisphere during the period in which it lived. And the proof of the existence of continental land in the Northern hemisphere acquires increased interest when we consider the evidence which shows what period this was.

The cardinal fact in that evidence is the occurrence of *Hyperodapedon* in the Coton-End Quarry in Warwickshire, as proved by Dr. Lloyd's specimen. It has never been doubted, I believe, that the Sandstone in which this quarry is excavated is of Triassic age. It has yielded Labyrinthodonts and Thecodont Saurians; and its stratigraphical position is such that the only question which can possibly arise is, whether it is Triassic or Permian.

As next in order of value, I take the discovery of *Hyperodapedon* in the Devonshire Sandstone, the determination of which as Trias rests, as Mr. Whitaker will inform you, upon independent grounds.

Thirdly comes the occurrence of the closely allied *Rhynchosaurus* in the Trias of Shropshire—a fact of subordinate value, but still by no means to be left out of sight.

These facts leave no possible doubt, as it seems to me, that *Hyperodapedon* is a reptile of Triassic age; but whether it is of exclusively Triassic age or not, and therefore whether it is, or is not, competent to serve as a mark of the Triassic age of the deposit in which it occurs, is quite another matter, and one respecting which it behoves us to speak very cautiously.

Crocodiles, with the same vertebral character as those which now live, and not known to be distinct even from the modern restricted genus *Crocodilus*, lived at the epoch of the Greensand, or, in other words, are common to two of the great divisions of geological time. The like is true of the Teleostean fish *Beryx*. Moreover it has been seen that *Hyperodapedon* is nearly allied to the living lizard *Sphenodon*, —as nearly, I am inclined to think, as to its Triassic congener *Rhynchosaurus*. And if this extraordinary form has persisted with so little modification from the Trias till now, why may it not have inhabited the dry land of the Permian, of the Carboniferous, or of the Devonian Epoch?

In discussing the question of the age of the Elgin sandstones in years gone by, reflections of this nature led me always to admit the possibility that these problematical beds might be of Devonian age; for *Hyperodapedon*, *Stagonolepis*, and *Telerpeton*, though clearly allied to Triassic and Mesozoic genera, were distinct from them, and had no stronger affinities with Mesozoic Reptilia, than the *Proterosauria* have (which yet are Palæozoic and not Mesozoic), or than some of the Labyrinthodonts of the Coal (e. g. *Anthracosaurus*) have with those of the Trias.

Even now that *Hyperodapedon* is distinctly determined to be a Triassic genus, the possibility that it may hereafter be discovered in Permian, Carboniferous, or even older rocks, remains an open question in my mind. Considerations of this kind should have their just weight when we attempt to form a judgment respecting the reptiliferous strata of the Karoo in South Africa, and of Maledi and elsewhere in India.

In India, *Hyperodapedon* occurs associated with Labyrinthodonts, with Thecodont reptiles (some of which have Crocodilian characters), and with Dicynodonts.

In South Africa, *Hyperodapedon* has not yet been discovered; but Labyrinthodont and Thecodont Reptilia (some of them Crocodiliform) have been found, and, associated with them, abundant Dicynodonts.

In England and Scotland, *Hyperodapedon* is found with Labyrinthodonts and Thecodont Reptilia of such distinctly Crocodiliform type as *Stagonolepis*, but no *Dicynodon* has been found.

In Würtemberg, Labyrinthodonts and Thecodont Reptilia, some of them, like *Belodon*, eminently Crocodilian, are associated together, probably with Dinosauria; but neither *Hyperodapedon* nor *Dicynodon* have yet been discovered.

All these four faunæ are connected by reptilian genera, which are respectively common to two of them: thus the British and the Indian by *Hyperodapedon*; the Indian and the African, by *Dicynodon*; the British and the German by *Labyrinthodon* (which according to Von Meyer occurs in Germany). The Labyrinthodonts and Crocodiliform reptiles are common to all four.

As the age of the beds in question is determined stratigraphically in Britain and in Germany to be Triassic, it may seem over-refinement to hesitate in declaring the African and Indian formations to belong to the same period; but I confess that the arguments I have mentioned lead me greatly to prefer some more general term, which should indicate a wider chronological range for the duration of the terrestrial fauna in question. The term *Poikilitic*, originally used by Conybeare to designate the Newer Red Sandstones of this country, seems to me to be very fit for this purpose; and in speaking of the Poikilitic period, I should like to make its earlier and later boundaries as hazy as possible, and to apply it exclusively to terrestrial conditions and to land and freshwater faunæ, without prejudice to the limits in time of the marine conditions known as Permian and Triassic.

It does not appear to me that there is any necessary relation between the fauna of a given land and that of the seas of its shores. The land faunæ of Britain and of Japan are wonderfully similar; their marine faunæ are in many ways different. Identical marine shells are collected on the Mozambique coast and in the easternmost islands of the Pacific; while the faunæ of the lands which lie within the same range of longitude are extraordinarily different. What now happens geographically to provinces in space, is good evidence as to what, in former times, may have happened to provinces in time; and an essentially identical land-fauna may have been contemporary with several successive marine faunæ.

At present, our knowledge of the terrestrial faunæ of past epochs is so slight, that no practical difficulty arises from using, as we do, sea-reckoning for land time; but I think it highly probable that, sooner or later, the inhabitants of the land will be found to have a history of their own,—mixed up with that of the sea, indeed, but independent of it, in some such relation as the histories of England and that of France.

If the terrestrial faunæ which I thus propose to term *Poikilitic*, were, in the historical sense of the word, contemporaneous, it would appear to be highly probable that, at their epoch, as at the present day, animals were distributed in distinct geographical provinces. It cannot well be a matter of accident that, with such uniformity in general *facies*, there is such diversity in detail between the four faunæ I have mentioned. And it is very interesting to remark that, just as at the present day, the Poikilitic fauna of India had distinct and independent relations, on the one hand, with that of Europe, and on the other with that of South Africa.

But I am disposed to think that there is a closer connexion than that of mere analogy between the geographical distribution of terrestrial animals in the Triassic epoch and that which obtains at the present day.

In the famous sandstones of the Connecticut valley, in North America, neither bones nor teeth have yet been discovered; but the foot-tracks show that either ornithoid Sauria, or true birds, or most probably both, existed in the Poikilitic period. Some of these bird-like creatures, such as the *Brontozoum*, were of gigantic size. They were associated with true reptiles, some of which, very probably, resembled the *Hyperodapedon* and *Rhynchosaurus* of western Europe.

With these facts before one's mind, how striking do the characters of the existing fauna of New Zealand appear! Its one characteristic reptile is *Sphenodon*, so extraordinarily similar to *Hyperodapedon*;

its most characteristic birds are the giant *Dinornithidæ*, some of which were competent to keep stride with the *Brontozoum* itself.

What if this present New Zealand fauna, so remarkable and so isolated from all other faunæ, should be a remnant, as it were, of the life of the Poikilitic period which has lingered on isolated, and therefore undisturbed, down to the present day?

I am quite aware that a host of difficulties may be opposed to this suggestion; but these all seem to me to be rather of the nature of questions which cannot be answered for want of information, than of objections formidable in themselves. For example, mammals existed in the Poikilitic epoch. Why did none of these inhabit the New-Zealand area and survive to the present day? Again, how comes it that the solitary amphibian of New Zealand is a Frog allied to those of South America, and not a Labyrinthodont? And why are the freshwater fishes also allied to, and, in one case, specifically identical with those of South America *, instead of resembling Triassic Ganoids?

I cannot give a direct answer to these questions, but I can show that analogous difficulties exist in cases where there can be no sort of doubt as to the origin of a fauna. Thus there can be no doubt that the fauna of Ireland is derived from the same source as that of Europe; but just as New Zealand is devoid of the class Mammalia, so is, or was, Ireland devoid of the class Reptilia; again, there is no indigenous British Ganoid or Siluroid freshwater fish, though both occur in the rivers of Central and Eastern Europe.

May it not be possible that causes similar to those which have shut out whole groups of Vertebrata of the European fauna of the present epoch from the British region, operated upon New Zealand in the Poikilitic period and caused its fauna to represent only a fraction of that of neighbouring lands? Or may it not be possible that causes such as those which determined the extinction of the indigenous horse, *Macrauchenia*, *Toxodon*, *Glyptodon*, &c. of South America, while they left multitudes of other genera alive, have similarly weeded down the fauna of New Zealand, and that investigations in the caves and superficial deposits of that country will yield forms which now no longer exist there?

I mention these possibilities simply for the purpose of showing how much greater value attaches to the positive similarities between the New-Zealand Fauna and that of the Trias than to their negative differences.

Finally, I may remark upon the complete modification of former ideas respecting the supposed poverty of life during the Poikilitic epoch which has been effected by the discoveries of late years.

It is now clear that all the five classes of the Vertebrata, viz. Mammalia, Aves, Reptilia, Amphibia, and Pisces, were represented at this epoch. The mammals were apparently Marsupials, not Monotremes. Of the birds nothing is known. Of reptiles, we have Dinosauria, Crocodilia, Dicynodonts, Lacertilia of several forms, Ple-

* I state these remarkable distributional facts on the high authority of Dr. Günther, F.R.S.

siosauria, and perhaps Ichthyosauria; of Amphibia, a great number of Labyrinthodonts, some of which were of enormous size; of fishes, Ganoids and Elasmobranchs.

So long as mammals and birds were known to occur no further back than the older Tertiaries, or the middle Mesozoic rocks, it might be legitimate to imagine that they came into existence somewhere between that time and the end of the Palæozoic series. But now that both are to be traced back to the Trias, that it is known that the Crocodilian and Lacertian types of reptiles were then in existence, and that the Amphibia were elaborately represented, I confess it is as possible for me to believe in the direct creation of each separate form as to adopt the supposition that mammals, birds, and reptiles had no existence before the Triassic epoch. Conceive that Australia was peopled by kangaroos and emus springing up ready-made from her soil, and you will have performed a feat of imagination not greater than that requisite for the supposition that the marsupials and great birds of the Trias had no Palæozoic ancestors belonging to the same classes as themselves. The course of the world's history before the Trias must have been strangely different from that which it has taken since, if some of us do not live to see the fossil remains of a Silurian mammal.

Discussion, see p. 157.

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2. *On the* Succession *of* Beds *in the* "New Red" *on the* South Coast *of* Devon, *and on the* Locality *of a* New Specimen *of* Hyperodapedon. By William Whitaker, B.A. (Lond.), F.G.S., of the Geological Survey of England.

The following account of the successive beds that are shown in the "New Red" cliffs of South Devon, is from notes taken during a holiday-walk along that coast last September, and it has been drawn up at the request of Prof. Huxley, in order to mark the stratigraphical place of the *Hyperodapedon* jaw from near Budleigh Salterton.

I believe that the only paper which treats of the order of these beds is a full report of two lectures by Mr. Pengelly, F.R.S.* To this I refer the reader for a more detailed account of the composition of the various "red rocks."

Owing to the dip, lower and lower beds rise to the surface southwestward, so that an almost continuous section is given.

The occurrence of the uppermost part of the "New Red" near the eastern boundary of the county, and its passage upwards into the Lias, have been noticed by Sir H. De la Beche †, and more fully by Mr. Pengelly ‡; but the cliffs here are so much hidden by fallen

* Trans. Plymouth Inst. for 1862–63 and for 1864–65.

† Trans. Geol. Soc. Ser. 2, vol. i. p. 42, and Plate 8 (1822). Report on the Geology of Cornwall, Devon &c. p. 209 (1839).

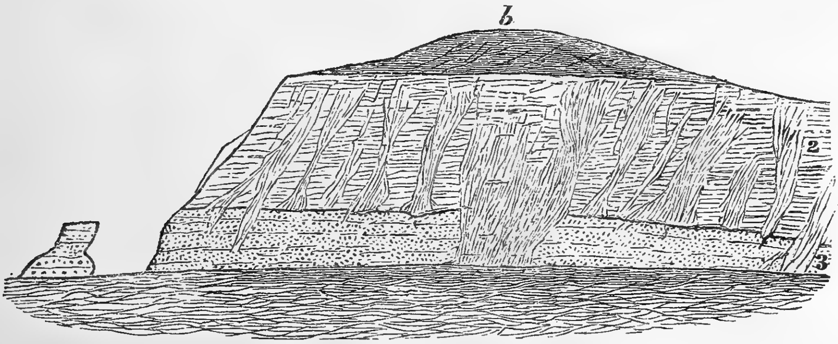
‡ Trans. Plymouth Inst. for 1864–65, pp. 33–36.

masses, that little is to be seen below the "White Lias" until we pass to the west of the great landslip of 1839 at Dowlands. The cliff is then clearer, and shows a set of evenly-bedded greenish clays, with black shales, stone-beds, and layers of hard marl (Rhætic Beds). Here Mr. Pengelly found the well-known bone-bed. Lower down some of the layers of clay have a reddish colour; and there is a passage downwards into "New Red" marl, which has greenish layers in its top part. The beds rise westward in gentle waves, bringing up lower beds in that direction, and the green layers decrease in number downwards, until at the mouth of the Axe there are but a few thin ones, nearly all the marl being of the usual deep red. This section, therefore, shows a passage from the "New Red" into the Rhætic Beds, and favours the view that the latter may be classed with the former just as well as with the Lias.

Leaving out these passage-beds, however, the red marl of Seaton is the uppermost part of the "New Red" of the South Devon coast; and it is, I believe, the only part that crops out along the cliffs westward to Sidmouth, where red sandstone rises up from beneath it in the cliff just east of the river. As the Greensand rests unconformably on the "New Red," it would be difficult, and perhaps impossible, to measure the thickness of the marl, and the more so as the section is much hidden by fallen masses.

This highest bed of marl does not come down to the sea-level westward of Sidmouth, and, indeed (except for a small patch noticed by Mr. Pengelly above the sandstone in Ladraham Bay),

Fig. 1.—*View of High Peak from the East.*



b. Greensand (overgrown, rough slope).
2. Red Marl, much furrowed by streams &c.
3. Red Sandstone, roughly bedded, much less furrowed.

ends off altogether in about a mile and a half. It forms, however, the greater part of High Peak, a fine mass, which is a good example of the way cliffs weather from above (fig. 1). The sandstone at the bottom is able to withstand the direct assault of the sea better than the marl above to resist the gentler attacks of subaërial actions; the marl is worn away into a number of furrows that mostly end at the top of the sandstone, which latter also forms a large isolated rock, surrounded by the sea (except at low water?).

The sandstone forms the whole of the cliff from Ladraham Bay to Budleigh Salterton, and on the left bank of the Otter it has, in parts, a brecciated character.

At Budleigh a bed of quartzite-pebbles, the thickness of which has been estimated at about 100 feet, crops up from below the sandstone, and rises westward to the top of the high cliff. This pebble-bed has been described by Mr. Vicary *, and the fossils of its pebbles by Mr. Salter †; so that no more need be said of it here.

Less than a mile from Budleigh a second thick mass of red marl occurs, and rises up from below the pebble-bed. In another mile a second bed of sandstone succeeds the marl, and forms the low headland of Straight Point ‡, halfway between the Otter and the Exe.

At the point of the headland the sandstone contains a thin bed of fine breccia; and on the western side it is underlain by a bed of marl 20 or 30 feet thick, which is succeeded by sandstone with beds of marl, from below which again, as the cliff turns at right-angles westward, marl rises. This last contains a few beds of sandstone, is a thick mass, and occurs for some way further.

West of the "Highland of Oscomb" (on the Ordnance Map), where the cliff turns northward for a little way, another bed of sandstone crops up, and is soon underlain by a last bed of marl.

Westward a tract of blown sand hides the rocks; but just out of Exmouth there is a low cliff of sandstone, most likely the top part of the sandstone and breccia on the other side of the Exe; indeed Mr. Pengelly has shown § that it must be so, from the fact that "in the undercliff, known as the 'Plantation,' below, and east of Beacon Terrace, the marl is found lying conformably on the conglomerate" (= breccia).

On the western side of the Exe we first meet with breccia, forming Langstone Point ||, with its natural arches. Thence to Dawlish the cliffs are of sandstone with layers of breccia; and beyond this the latter increases at the expense of the former, until, north and south of Teignmouth, the cliffs are almost wholly formed of it. Of this singular thick mass of breccia, the lowest part of the "New Red" of Devon, Mr. Pengelly says, "We have in Torbay conglomerates [= breccias] and sandstones, with a few thin layers of marl. There is no very decided order of succession; but on the whole the sandstones may be said to preponderate. Wherever the base of the formation is seen, however, it consists of very coarse conglomerate. . . From Petitor . . . to near Dawlish the cliffs consist of conglomerates, with a few beds of sandstone" ¶.

In the above sketch, which is summarized in the section (fig. 2), no notice has been taken of the few faults that occur: these are nearly all very small, and none are of importance.

* Quart. Journ. Geol. Soc. vol. xx. p. 383.

† Quart. Journ. Geol. Soc. vol. xx. p. 386, and Geol. Mag. vol. i. p. 5.

‡ Not named on the Ordnance Map.

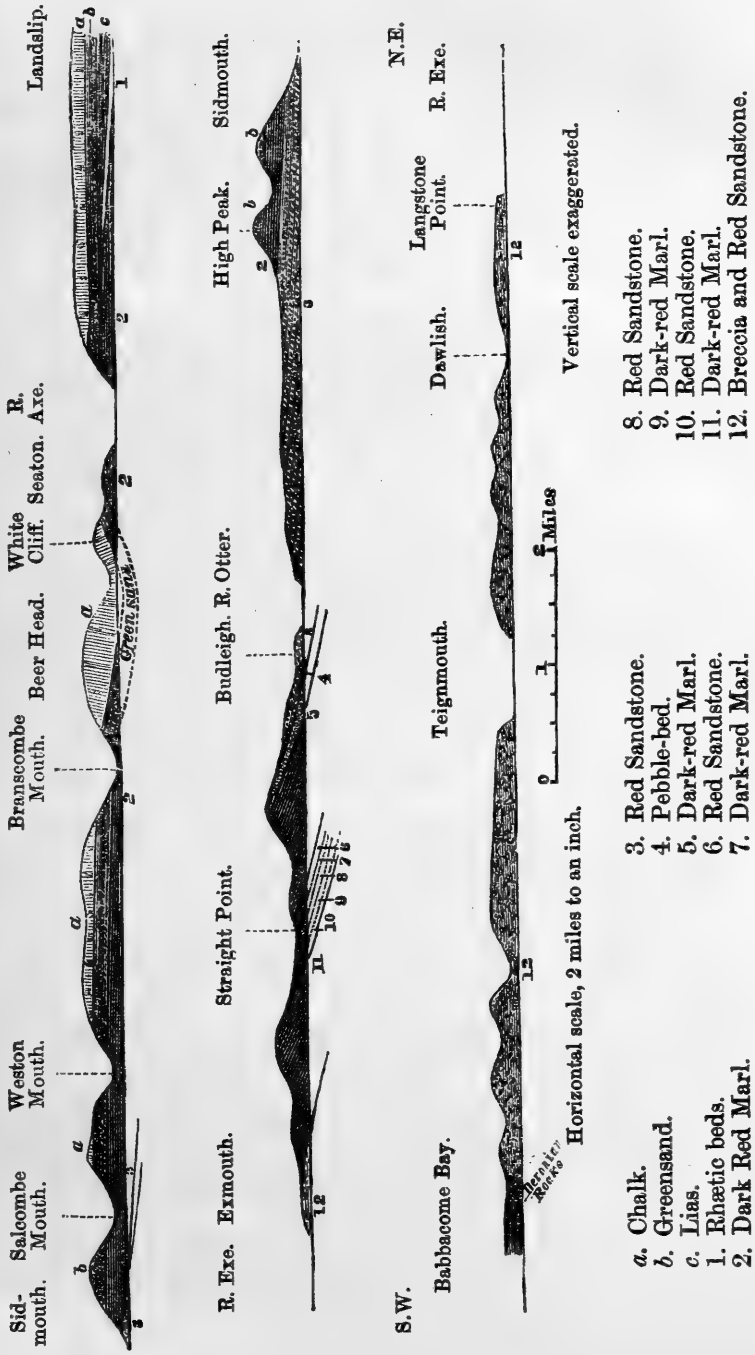
§ Trans. Plymouth Inst. for 1864–65, p. 34.

|| Not named on the Ordnance Map.

¶ Trans. Plymouth Inst. for 1862–63, pp. 15, 16.

It would be a work of time and trouble to measure the thickness of each division; perhaps, indeed, it would be impossible to do so at all accurately; but I must draw attention to Mr. Pengelly's cal-

Fig. 2.—*Section along the South-Devon Cliffs from the Dowlands Landslip to Babbacombe Bay.*



culation (from the dip and breadth of outcrop), according to which the whole formation *may* have a thickness of four miles or more *,

* Trans. Plymouth Inst. for 1862–63, pp. 28–30, and for 1864–65, pp. 40–46, and Trans. Devon. Assoc. of Lit. Sci. & Art for 1863.

although he allows that this is most likely much too great an estimate. We may safely say, however, that the total thickness is some thousands of feet.

The spot that yielded the jaw of *Hyperodapedon*, the first and, as yet, the only fossil of the "New Red" of Devonshire, is on the left bank of the Otter, just above its mouth, where the sandstone is somewhat brecciiform. The specimen was in a large block which had fallen from the low cliff that bounds the estuary, and was found by my friend Mr. J. Reid, of Canterbury, and myself.

The stratigraphical position of the fossil is therefore the lower part of the uppermost bed of sandstone (No. 3 of section), and consequently it belongs to the upper part of the formation.

That the upper part of the "New Red" of this county belongs to the Trias is clear from its passage upwards into the Lias; and as the different divisions seem to succeed each other conformably, we are led to infer that they all belong to the same formation, although the lowest division is more like the Permian of some districts. Mr. Pengelly has gone into the question of the age of the breccia of Teignmouth &c. in detail *; and it will be well to give the leading points of his argument, which are as follows, to state them in as few words as possible:—

The Dartmoor granites are thought to be of three different ages, the newer cutting through the older. All of these send veins into the Carboniferous rocks, and are therefore newer than that formation. Fragments of all three granites have been found in the "New-Red" breccia. Therefore, between the time when the Carboniferous rocks were consolidated and the time when the "New Red" began to be deposited, the following events must have taken place:—1. All the three sorts of granite must have been successively formed. 2. The thick crust above them must have been denuded to allow of pebbles being worn out of them. These things must have taken vast time —time so great as to make it very unlikely, if not impossible, that even the lowest part of the red rocks can be Permian.

The above reasoning seems conclusive, as far as it goes, and indeed can only be shaken by attacking the data on which it is founded. One of these data is a tacit assumption that there was no very great time, geologically speaking, between the close of the Carboniferous and the beginning of the Permian period. My colleague, Mr. Hull †, has since shown, however, that in Lancashire and Yorkshire there is a great unconformity between the rocks of those ages, and that the Carboniferous rocks have in parts been denuded to the extent of very nearly 10,000 feet in vertical thickness, and perhaps at one part to the extent of more than 19,000 feet, before the deposition of the Permian beds. When it is remembered that this great denuda-

* Trans. Plymouth Inst. for 1861–62, pp. 27–30, and Presidential Address to the Devon. Assoc. of Lit. Sci. & Art, 1867.

† Quart. Journ. Geol. Soc. vol. xxiv. pp. 327–329.

tion also implies the previous consolidation and uptilting of the beds, I think it must be allowed that very great time passed between the two periods. Perhaps, therefore, the Devonshire breccia may be older than has been thought. At first Mr. Pengelly classed the lower part of the Devon "New Red" as Bunter (the lowest division of the Trias); but afterwards the conformity of the beds, without any apparent break, led him to think that all must belong to one division of the Trias (unless all three are represented), and that one the uppermost (Keuper), on account of the passage up into the Lias.

As to the beds with which we are here concerned, from their being the resting-place of *Hyperodapedon*, there can be little doubt that they belong to the Keuper; indeed Mr. G. W. Ormerod, F.G.S., has inferred, from the occurrence of "waterstone-beds" and of pseudomorphs of rock-salt crystals, that the whole of the beds east of Exmouth (that is, all except the great breccia &c. of Dawlish and Teignmouth) are of this age*. I think however that it would be hardly safe to conclude that all the "New Red" of Devonshire belongs to one member of the Trias, or even that its lowermost division may not be a glacial breccia of Permian age.

Discussion.

Sir R. I. Murchison argued in favour of the overwhelming importance of palæontological evidence, and maintained that *Hyperodapedon* was Triassic. He objected to the use of the term "poikilitic," which was merely indicative of the spotted character of the beds, and protested against the mingling of the Permian and Triassic series.

Sir Charles Lyell, referring to the occurrence of *Hyperodapedon* with *Stagonolepis* and *Telerpeton* in the uppermost sandstones of Elgin, remarked that he came to the conclusion that these beds were Triassic in 1859, and that Mr. Symonds had in that year stated them to be the equivalents of the *Rhynchosaurus*-sandstones of Shropshire.

Professor Ramsay regarded the Red Marls and Sandstones described by Mr. Whitaker as Keuper, and the lower members of his section as of Permian age. He confirmed Prof. Huxley's views as to the existence of a great extent of continental land at the epoch when *Hyperodapedon* and the Reptiles associated with it were in existence, and remarked that these Reptiles inhabited the shores of the great salt lakes of the Triassic land. He objected to the use of the term "poikilitic," and remarked that if the idea embodied by Prof. Huxley under it were to be accepted, it would have to be extended to all terrestrial deposits from the Silurian period to the present day.

Dr. Günther referred to his description of *Sphenodon* (=*Hatteria*), and remarked that in that genus there are uncinate processes on the ribs, as in Birds, which do not exist in *Hyperodapedon*. He

* Trans. Devon. Assoc. Lit. Sci. & Art for 1868, and Quart. Journ. Geol. Soc. vol. xxv. p. 50 (February 1869).

remarked upon the resemblance of the beak in the latter to that of the Tortoises, especially *Trionyx*, and suggested that the jaws might have had a horny covering.

Dr. Meryon inquired as to the implantation of the teeth in the jaws of *Hyperodapedon*, and suggested that the position and direction of the orbits were not accordant with terrestrial habits, and also that the absence of processes on the ribs indicated a flexibility of the body consistent with a fluviatile mode of life.

Prof. Huxley showed that no conclusion could be drawn from the want of processes on the ribs or the position of the orbits as to the habits of the animal, and remarked that the processes in *Sphenodon* were not anchylosed to the ribs; he considered it possible, but not probable, that the jaws had a horny covering. He stated that in using the term "poikilitic," he was desirous of indicating that while several marine formations with changing forms of life succeeded each other, the terrestrial fauna may, in certain cases, have been continuous. He believed that terrestrial forms were at least as persistent as marine.

Mr. Carruthers remarked that the Permian vegetation showed Mesozoic affinities, and in fact that the commencement of the Mesozoic flora was to be sought in the Permian.

January 27th, 1869.

Arnold Lupton, Esq., Salter Gate, Chesterfield, and Dr. George Rogers, of Longwood Asylum, Bristol, were elected Fellows of the Society.

The following communications were read:—

1. *Notes on* Graptolites *and allied* Fossils *occurring in* Ireland. By William Hellier Baily, F.L.S., F.G.S.

The remarks I am about to offer upon a group of fossils of great importance in determining strata of Silurian age is principally intended to record the species I have been enabled to identify in Irish strata. I shall avoid discussing the question as to the exact position Graptolites occupy in the animal kingdom, except to observe that the preponderance of evidence is in favour of their alliance with the Hydrozoa; nor will I give any details of their structure, this subject having been lately so ably discussed by Mr. William Carruthers in the new edition of 'Siluria,' and in his paper entitled "A revision of the British Graptolites"*. Dr. H. A. Nicholson has also added considerably to our knowledge of this interesting group of extinct Zoophytic organisms.

I will now briefly allude to the localities in Ireland where these fossils occur, nearly all of them having been visited by me, and

* Geological Magazine, vol. v. p. 64 (1868).

numerous specimens examined in connexion with my duties on the Geological Survey of that country.

Commencing with the south of Ireland, the first place to be noticed is in the county of Waterford, on the banks of a stream called the Dalligan river, five miles N.E. of Dungarvan, where dark grey argillaceous shales occur full of the small diverging Graptolite, *Didymograpsus sextans*, Hall; they were first discovered at this place by Mr. Charles Galvan, of the Geological Survey. In the list of fossils, appendix to 'Siluria,' 1867, the geological range of this species is limited to the Llandeilo group of rocks. Proceeding towards the city of Waterford, at Lady Elizabeth's Cove, in Tramore Bay, highly inclined black slates dipping 80° N.E. may be seen on the shore just below high-water mark, penetrated by a greenstone dyke and in close proximity to rocks containing a profusion of fossils of Caradoc-Bala age; these slates are of a dull earthy character, much impregnated with pyrites, and yielded the following species:—

Graptolithus Hisingeri, *Carruthers* (= sagittarius).
*Didymograpsus sextans, *Hall.*
Cladograpsus gracilis, *Hall.*
Diplograpsus pristis, *Hisinger.*
Climacograpsus bicornis, *Hall.*
Dicranograpsus ramosus, *Hall.*

together with the following reticulated and many-branching forms, the affinities of which to Graptolites I agree with Mr. Carruthers in considering to be very doubtful,—

Dictyonema, sp.
Callograpsus elegans or Salteri.
Dendrograpsus flexuosus or diffusus.

At a second locality, in Tramore Bay, *Diplograpsus pristis* occurred in grey slate, associated with Trilobites.

A little north-west of the town of Waterford, on the left bank of the river Suir, are cliffs 150 feet in height, composed for the most part of unfossiliferous Silurian flags and slates, penetrated by masses of Greenstone Porphyry; at the base of the cliff, which is here called the Bilberry rock, a mass of much-jointed and finely laminated dark grey slates, highly inclined, and in some parts stained red and yellow, were to be seen when I visited the place some months since; as, however, it, with the flaggy beds immediately adjoining, was being quarried away, this fine Graptolite-locality may soon disappear, or has perhaps already disappeared. These slates are crowded with well-defined, although much compressed Graptolites; and as the layers separate with great facility, good specimens were readily obtained. The species are few, but abundantly repeated, *Diplograpsus pristis* being the most numerous: it occurs with prolonged axis and proximal termination. The next species in point of numbers is a diverging form, the initial process being well shown in some examples which I believe to be identical with the species Dr. Nicholson figures †, and refers to *Didymograpsus* (*Graptolithus*) *flaccidus*, Hall. Mr. Carruthers has described this species under the name of *Didymograpsus elegans*, doubting its identity with Hall's species; I agree with him

* The asterisks prefixed to species indicate their comparative abundance.
† Annals and Magazine of Natural History, ser. 4, vol. i. pl. 3. fig. 14.

in believing it to be distinct, the proportions of the polypary being much greater, and the number of serratures to the inch not much more than half those in *G. flaccidus* as described by Professor Hall. The only other species observed at this place was a single-celled form, which I have with some hesitation referred to *G. Hisingeri* (=*sagittarius*).

At Newtown Head, Waterford Harbour, a single-celled Graptolite occurs sparingly with numerous Caradoc-Bala fossils; this I have doubtfully referred to *G. priodon*.

In the adjoining county of Wexford there are several good Graptolite-localities, mostly in rocks on the shore of Courtown harbour. At Ballymoney, near Gorey, black slates occur with *Diplograpsus pristis*, much distorted by cleavage; and a little south of Ballymoney fishery the following species were collected,—

Graptolithus Hisingeri ? (=sagittarius).	Diplograpsus mucronatus.
Didymograpsus sextans.	—— teretiusculus.
—— flaccidus.	Dicranograpsus ramosus.
Diplograpsus pristis.	

At Ballinatray, near Gorey, fine examples of *Dicranograpsus ramosus* were collected. West of Ballinatray the black slates, much distorted by cleavage, contain an abundance of *Diplograpsus pristis*, accompanied by *Cyrtograpsus gracilis*; and a little south of Breanoge Head, near Courtown, a Graptolite, which I have referred to *G. Sedgwicki*, was collected by Mr. Galvan from a compact greenish slaty rock, such as Graptolites are not usually found in. At Tinnaglogh, four miles N.N.E. of Duncannon, Wexford, the black argillaceous slates abound with *Diplograpsus pristis* in a very perfect condition, showing prolonged axis and proximal termination. At Churchtown, one mile north of Tagoat, and about 7 miles S.S.E. of Wexford, the remarkable little branched Graptolite *Didymograpsus caduceus*, Salter, is not uncommon, accompanied by what I believe to be *Graptolithus Hisingeri* (=*sagittarius*), and associated with fossils of Caradoc-Bala age.

In the south-west of Ireland a few miles north of the city of Limerick, and near Six-mile Bridge, in the county of Clare, a remarkably rich locality for Graptolites was discovered by Mr. G. H. Kinahan, of the Geological Survey of Ireland, on the western flank of the Slieve Bernagh mountains. The rocks consist of black-argillaceous slates, readily separating into laminæ; the fossils are disclosed in the most perfect condition, the prevailing species being *Diplograpsus pristis* in all its varieties, resulting from pressure in various directions: examples having very long filamentary processes proceeding from the mouth of the cells appear to me to be identical with Hall's figures of *D. mucronatus*; this and *D. dentatus*, Brongniart, may, however, be only a more perfect condition of *D. pristis*. It is probable that the bodies I have figured and described as *Theca cometoides*, from this place*, may be, as suggested by Mr. Carruthers,

* Journal of the Geological Society of Dublin, vol. ix. 1861, pl. 4. fig. 8.

gonophores or generative buds of Graptolites (possibly of *D. pristis*), and that they are analogous to those of the Sertularidæ, as in *Sertularia fallax, pumila*, &c.*

The following are the species from this locality.

***Diplograpsus pristis.
—— mucronatus, prob. synonym.
—— bicornis, *Hall*, with appendages at the proximal end as figured by Mr. Carruthers under the name of *D. pristis.*
Didymograpsus sextans.
*Cyrtograpsus gracilis (*Hall*). This pretty branching species, not uncommon at this locality, is easily recognized from Hall's figure†, as characterizing the Utica slate and Hudson-River groups: of the single serrated forms, the remaining species are
Graptolithus Hisingeri (=sagittarius).
—— tenuis.

About one mile and a half from this locality, and two miles south-west of Broadford, in the same county, single-celled Graptolites only were collected; these I have referred to *G. priodon.*

In the townland of Kilnacreagh, three miles east of Six-mile Bridge, the species observed were *Graptolithus priodon* and *tenuis*, with a diverging form referred to *Didymograpsus Forchhammeri*, the accompanying fossils being of an Upper-Silurian type.

At a few other places in the same county, and near to the last-named locality, there are similar Graptolites associated with Upper-Silurian fossils, as at the Townland of Glenagross, three miles and a half E.S.E. of Six-mile Bridge, where *Graptolithus priodon* is found associated with *Cardiola interrupta* and a Crinoid allied to, if not identical with, *Actinocrinus pulcher*, a Wenlock species.

At Trough Cottage, Clare, 6 miles east of Six-mile Bridge, *Graptolithus priodon* occurs associated with the same Crinoid. Half a mile E. of the preceding locality, in the same townland, *Graptolithus priodon* and *G. tenuis* were the species observed.

In the adjoining county of Tipperary, Mr. A. B. Wynne (now of the Geological Survey of India), whilst surveying the district, discovered many fossil localities; at several of them Graptolites occurred associated with Upper-Silurian fossils, such as *Euomphalus discors*, *Cardiola fibrosa* and *interupta*, *Orthoceras*, &c. *Graptolithus priodon*, the characteristic Upper-Silurian species, and most abundant of the single-celled forms, occurs at the following localities in this county, viz.:—at Boosnafarney; Cloncannon; Big Park, near Latteragh; Knocknagoogh, S.E. of Latteragh, in profusion; N.W. of Barnane House in an uncompressed state; Garrangreena; Gortnaskea; Curreeny common, &c.; and, accompanied by *Graptolithus tenuis* and *Graptolithus Hisingeri* (=*sagittarius*) at Reaghfadda.

The pretty little branching species, *Cyrtograpsus hamatus*, Baily, sp.‡, was collected by Mr. Wynne at Garrangreena and Kilmacuddy, in the same county.

On Knockshigowna Hill, nine miles north-west of Roscrea, Tip-

* Johnston's British Zoophytes, 2nd edition, p. 72, fig. 12, p. 73, pl. 11. figs. 2–4.
† Palæontology of New York, vol. i. pl. 74. fig. 6.
‡ Journal of the Geol. Society of Dublin, vol. ix. pl. 4. fig. 6.

perary, *Graptolithus priodon* is remarkably abundant in close proximity to fossils of an Upper-Llandovery type.

With the permission of the Society, I shall reserve for another occasion the continuation of this subject, when I hope to have been able to complete my examination of localities in the north of Ireland, some of which are of great interest.

Discussion.

Mr. Carruthers remarked that while almost all observers have referred these creatures to the *Hydrozoa*, there was an impression abroad, founded on a misconception of a remark of Prof. Huxley's, that he classed them as *Polyzoa*. He had, however, Prof. Huxley's authority for saying that he did not so regard them.

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2. *Notice of* Plant-remains *from beds interstratified with the* Basalt *in the county of* Antrim. By W. H. Baily, Esq., F.G.S.

(Abstract.)

The deposit referred to by the author was discovered by the late Mr. G. V. Du Noyer in cuttings of the Northern Railway of Ireland, near Antrim; the plant-layer consists of a red clay deposit from 4 to 8 inches in thickness, separated by a bed of 10 or 12 feet, containing nodular iron-ore, from the underying basalt, and by earthy beds of about equal thickness from the superficial basaltic rock.

The author regarded a large cone as that of a true *Pinus*, and branches of another coniferous tree as belonging to a *Sequoia* nearly allied to *S. Sternbergi*, Heer; of this species he thought a small imbricated cone might possibly be the fruit. Other fragments of Coniferæ seem to belong to *Cupressites* or *Taxites*. The fossils consist chiefly of leaves of true Dicotyledonous plants. The author compared some of them with species of *Rhamnites*, *Olea*, *Fagus*, and *Quercus*. Leaves of endogenous plants, such as Sedges and Grasses, occur not unfrequently. A large mass of fossil wood of dicotyledonous structure was obtained from the hæmatitic deposit. Seed-like bodies are also found. The plant-remains are accompanied by by a few elytra of Beetles.

The author remarked that these plant-remains differ as a group from those of the island of Mull. Their alliance appears to be with Mid-European forms; and they are certainly of Upper-Tertiary age, probably Miocene.

Discussion.

Mr. Carruthers observed on the difficulty of determining species, or even genera, satisfactorily, from such fragmentary evidence as that adduced by Mr. Baily. He considered that the small cone did not belong to *Sequoia*, inasmuch as the cone of *Sequoia* was not composed of imbricated, but of adnate, peltate scales. The wood was not only dicotyledonous, but coniferous.

Mr. David Forbes remarked that the existence of this leaf-bed would formerly have been regarded as affording grounds for belief in the non-igneous origin of basalt. He had, however, made experiments as to the non-conducting-power of clay, and had found that even half an inch of clay was sufficient to protect vegetable forms from destruction by the heat of a mass of slag allowed to flow over them. In the same manner he had found the forms of leaves still preserved under the lava of Vesuvius and other active volcanoes.

Mr. R. H. Scott called attention to the work of Dr. Heer on the specimens brought home from Greenland by Mr. Whymper, among which he had recognized the fruits of various plants which had already been identified by him from the leaves. The connexion between these beds and those of Bovey Tracey, Oeningen, and other Miocene deposits throughout Europe was now proved; and the collections just brought home from Spitzbergen by the Swedish Polar Expedition would throw further light on the subject. No doubt further discoveries would also be made of a similar character in the north of Ireland. He pointed out the similarity between the Irish section and those of Greenland, where vegetable remains were also found interstratified with basalt.

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3. Remarks *upon the* Basalt Dykes *of the* Mainland *of* India *opposite to the* Islands *of* Bombay *and* Salsette. By George T. Clark, Esq., F.G.S.

The following remarks are the result of observations made during the years 1845–6–7 upon the trap rocks of a part of the Bombay Presidency. They were laid aside as being, at that time, of no great interest in England, and are slightly alluded to in a letter from the writer to Dean Buckland, not intended for publication, but which was printed in the Quarterly Journal of the Geological Society for January, 1847 [vol. iii. p. 221].

The paper now offered to the Society was written in that year. Some recent remarks by Mr. A. B. Wynne upon the letter to Dr. Buckland induce the writer now to bring it forward. Whatever value it may possess is derived chiefly from the fact that it relates to a district but little known, geologically, and which, from the difficulties of climate and other local circumstances, is less accessible than might be expected from its easy distance from Bombay.

The physical features of Western India are very peculiar. The surface of the peninsula rises very gradually from the Bay of Bengal to an irregular line ranging north and south from twenty to fifty miles from the western coast. At this line the ground, there very high, terminates in an escarpment of from 100 to 1000 feet in depth, and more or less precipitous. The strip of land intervening between this escarpment and the western sea, though of irregular surface, and containing several lofty spurs from the high ground, and some detached ridges, is on the whole not very much above the sea-level.

These features naturally divide the country into the district above the escarpment, called the Deccan, and that below it, called the Concan. The escarpment itself is known as the Syadree Range or Western Ghauts.

The Ghauts, therefore, are a vast escarpment and not a regular mountain-range. Upon this escarpment, however, there occur mountains of from 4000 to 5000 feet high; and connected with it there are several long and lofty hill-ranges, passing from it eastwards and declining as they recede.

The escarpment, generally precipitous, contains several special precipices of from 1000 to 2000 feet in height, the crests of which are at least as far advanced as their bases, and in a few very remarkable cases, as at Hurreechunder, actually overhang them.

For many miles north and south of Bombay, and for many miles inland, the rocks of the district are, with limited exceptions, of igneous origin, and varieties of trap.

It is not the object of this paper to explain the general geology of this district; but it may be observed that there is evidence to show that a line or band of volcanic vents extends north and south up the axis of the Concan, whence most of the trap of Western India appears to have been poured out,—eastward, at a moderate slope to form the Deccan; westward, at a much steeper inclination, into the sea. There are also appearances connected with these vents which seem to explain the great and sudden difference of altitude between the country above and that below the Ghauts, as well as the singular fact that the Ghauts themselves do not appear to have been produced by, or to be in any way connected with, any line of upheaving, or of fault, or with any similar disruption or displacement, local or general.

The dykes under consideration are no doubt mineralogically interesting; but they are far more so from their connexion with the various vents in the great volcanic band, and because they form a part in the chain of evidence upon which the theory of the formation of this very remarkable part of India must rest.

The dykes by which this part of the Concan is traversed vary in breadth from one and two to ten, twenty, forty, and occasionally 100 or 150 feet, and are often many miles in length. They are most numerous about the centre of the Concan. They are also numerous in the great valley or bay known as the Malseje Ghaut. They are seen, though less frequent, beneath the Nana, Copolee, and Beema-Sunker Ghauts, and in the road between Panwell and the Bhore Ghaut. Many occur upon the Ghauts themselves, and a few above them upon the high tableland of the Deccan. They have also been traced in the islands of Bombay and Salsette.

The contents of a few of these island dykes, and of one or two upon the shores of the Concan, are altogether peculiar; but with these rare exceptions the dykes present very many points of resemblance. They are basaltic; all have a tendency to the prismatic form, which now and then, as at Gorabunder, in Salsette, and at Callian, becomes columnar. The axes of the prisms are always at right angles to the face, or plane of cooling, of the dyke. Almost all are subdivided by planes parallel to that plane, into bands; and in most of the larger dykes the interior bands are more or less concretionary. All are much jointed, evidently in cooling, and are fissured, or readily fissile, to great minuteness. The fragments, almost always freely scattered about along the course of a dyke, are commonly flat triangular prisms, having two faces of unequal breadth, but much broader than the third, and consequently containing a very acute angle. The material is very dense and clinking, and, so far as I have observed, is never amygdaloidal, nor, excepting in a very few cases, vesicular. This is remarkable, since four-fifths of the rock through which the dykes pass is highly amygdaloidal.

These dykes have been traced through every rock from beneath the sea-level up to the crests of the Ghauts, and nearly to the summit, geologically, of the highest outliers of the Concan. They are found 4000 feet above the sea upon Hurreechunder, and at full 3000 feet between the Malseje and Joodhun. They have not hitherto been observed in the basalt capping of Beema-Sunker; and therefore their relation to that bed is uncertain.

Except in a few and local instances, I have been unable to detect anything like the effects of secondary fusion in the minute structure of the trap beds cleft even by the larger dykes, though these beds, being amygdaloidal, might be expected to show some traces, even mechanical, of the great heat to which the dyke must have exposed them, whether this occurred before or after the deposition of the zeolite. Viewed in mass, it is, however, evident that the trap on either side of each dyke has, for some distance, been hardened or rendered tougher by its heat, and has thus been enabled to oppose special resistance to the eroding forces. Hence when the dykes traverse a trap plain, their course is usually indicated by long and lofty, though often narrow ridges of rock, of which the dyke forms the axis, and which from their superior toughness have resisted the general removal of the surface. The actual course of the dyke itself is usually marked by a depression, the prismatic structure allowing it, however hard the rock, to be removed in fragments. In a very few cases planes of fissure or cleavage are observed in the trap parallel to a dyke, and apparently due to the secondary fusion of the trap by the dyke.

The plane of separation between the dyke and its containing rock is, commonly, well defined. There is no fissure, but there is no adhesion. Sometimes branch dykes come off, and almost always at an acute angle.

The ordinary structure of these dykes seems to be homogeneous. The grain is usually fine, though now and then coarse and open. Occasionally they contain crystals of a honey-coloured mineral. Some are pitted superficially, where exposed to the weather, no doubt by the decomposition and removal of this mineral. One dyke near Callian affects the magnetic needle considerably; and a few others do so in a less degree. One or two of the Callian dykes are contained between a sort of selvage made up of plates of about one-eighth of an inch thick, but with the planes of separation of each plate set at right angles to the course of the dyke. These plates appear to be of different material from the dyke itself; and where this affects the needle they do not partake of that quality. In aspect these selvages resemble greenstone, although so closely connected with the basalt. They may, no doubt, represent a band of trap, fused by the dyke, or more probably a part of the dyke itself, which, under electrical action, has assumed this structure.

The general direction of the dykes is more or less nearly parallel to the bands of volcanic vents, main or subordinate, near to which also they are most numerous. Hence, although this rule has, as was to be expected, many exceptions, the greater number of the dykes near to the central axis of the Concan range north and south, and those near the subordinate band in the Malseje Valley range more nearly E.N.E. and W.S.W. In both, as in the adjacent districts, occur a few dykes taking other directions; but out of thirty-nine dykes, thirteen range north and south, and sixteen between N.E. and E. and S.W. and W. Three only lie S.E. and N.W.

The plane of each dyke is usually vertical; and the exceptions are few and local. Also they range in straight or nearly straight lines. They now and then swell out or contract, and in one or two instances have been observed to include a rider, though commonly their faces are parallel. They are very seldom indeed connected with any vertical displacement of the rocks; and the few exceptions to this are of very limited extent. I have not observed any dyke to be connected with a considerable fault.

Though the basalt of the dykes is peculiarly hard, and undergoes very little disintegration from the weather, its fissile character leaves it with little power of resisting eroding forces; and, in consequence, although sometimes a dyke stands up, out of the trap ridge already described, as a rugged black wall, more commonly its position is marked by a depressed furrow along the top of the ridge, the sides of which are thickly strewed with its fragments.

The most precipitous passes across the Ghauts are those produced by the removal of the dykes. In such cases the pass is a vast fissure, the walls of which are perpendicular and parallel, sometimes 300 or 400 feet high, and not above 10 or 20 feet apart. These walls are almost as hard as the removed basalt, and, not being fissile, are much less readily disturbed. Here the lower or unremoved part of the dyke forms the rough steps up which such passes are ascended. The "Nisnee cha Dara," or "pass of stone," near Jooneer is a very fine example of such a pass.

Owing to this same hardening of the trap, the course of a dyke across a river is often marked by a bund or dam, which the people turn to advantage for the irrigation of their lands. There are several such near Moorbar; and the navigation of the Callian river is seriously impeded by such an obstruction a few miles below that town.

These dyke ridges form rather a leading feature in the topography of the Concan. Some resemble raised causeways, and are so used during the rains; others have all the regularity of an artificial earthwork; and many traverse the country for miles together, varying from one to two or three hundred feet in height, but always narrow. Near Moorbar a number of these ridges intersect each other, and form some very singular triangular enclosures.

The dykes are observed not only near to the parallel of Bombay, but they are seen in great numbers both north and south of that line, and still present the same characters. A sufficient number of dykes have been traced up from the Concan to the crests of the Ghauts to make it clear that elevations of 3000 and 4000 feet produce no perceptible difference in their structure or density.

The dykes are less numerous and of a smaller size as they recede from the volcanic district. East of the Ghauts, therefore, they are not numerous. Perhaps half a dozen have been noted between the Ghauts and Poona, and none between Poona and Shoolapoor. North of Jooneer, or rather of the Hurreechunder range, they are said to be more frequent, and to be found of large dimensions 50 or 60 miles from the sea. If this be so in these as well as in the more eastern examples in the metamorphic districts, it seems probable that such dykes are not to be traced to the Concan vents, but to sources more to the eastward—sources independent above, though, no doubt, identical below.

It may be mentioned that where fissures in a lava stream have been filled up by the overpouring of a later stream, the included matter, probably from its contact with cooled surfaces, assumes a denser structure than either its parent or including rock, it is, as founders say, "chilled;" and when the parent and superincumbent mass is swept away, what is left much resembles a regular dyke. Many such occur in the Deccan, but they are usually on a small scale, zig-zag, and may be readily traced to an end.

There seems every reason to believe that basalt dykes belong to a very late, perhaps nearly the latest, period of general volcanic action in the vast cape of India. The regular basalt beds which they resemble have not been observed lower than near to, if not at the very summit of, the series upon the Ghauts, and at the actual summit in Bombay—that is to say, on the two remaining margins of the volcanic region. The Bombay basalt, indeed, seems precisely to resemble, mineralogically, that composing the dykes, and to differ only in the local accident of a more perfect rhomboidal and columnar structure, due, no doubt, to its mass. The Ghaut sheet-basalt, well seen on the great tableland upon and east of Beema Sunker, is rather prismatic than columnar, and it contains the honey-coloured mineral and affects the needle. In the possession of these two qualities it differs from the basalt of the adjacent dykes; but I know not if this be fatal to their general identity, or at any rate to their being regarded as of one general period. The nodular basalt common as a capping-bed on the hills near Poona and the Beema is certainly cleft by the dykes. Upon Beema Sunker, and, I believe, elsewhere at great altitudes, beds of laterite, or of an amygdaloid much resembling it, are found above the basalt-bed. I know not whether these beds are reached or cleft by the dykes.

The dykes are observed to traverse and to pass at tangents to particular vents, and, although most numerous about such points, not to radiate from them. Nor do such vents present any traces of a flux of regular basalt. From this it seems reasonable to infer that the dykes are due not only to a later period, but to a period after the cessation of the regular eruptive action, and possibly therefore that the capping beds may be the overflow of the dykes.

Salsette, indeed, seems to be an exception, and to contain evidences of still later eruptive action, though local only.

The dykes themselves seem to admit of division into at least two periods, since dykes of different grain frequently intersect each other. Near Moorbar these intersections are most numerous; but at such points the rock is commonly very loose, covered with jungle, and full of poisonous snakes; they are therefore difficult of examination. I think, however, that in many cases the dykes lying north-east and south-west traverse and often very slightly dislocate those lying more nearly north and south; whence I infer these to be the later, and the cross band of the Malseje vents to have ejected its dykes since those connected with the general outline of the Ghauts. It is probable, however, that a minute examination of specimens from all these dykes would throw more light upon this matter.

The dykes, as has been stated, are neither vesicular nor amygdaloidal, although they pass through rocks most of which are both one and the other. But though the basalt contains no vesicles, it is fissured in all directions, and must have been fissured, more or less, very soon after it was poured out, as it began to cool. All the contiguous rocks contain kernels of zeolite, and now and then of chalcedony and calcareous spar. None of these minerals are found in the basalt, although its cracks must have lain open to receive them. I do not know what is the prevailing theory upon the deposition of these included minerals; but these appearances seem to point to their segregation from the trap, and to be opposed to any theory of infiltration.

Among the dykes alluded to as not basaltic may be mentioned one on Trombay Island, which branches off from a basalt dyke, but is quite void of the mineral, and contains laumonite.

In most cases the great and numerous fissures, so common on the Ghauts, mark the passage and removal of a dyke. This is not always the case; and hence there seems ground to suspect that the fissures may have been formed, not by the forcible injection of the basalt, but independently of and before its appearance.

Discussion.

Mr. David Forbes did not see any proof of the dykes being of different ages. In modern eruptions, lasting over some years, the lava first erupted sometimes became fissured, and the fissures filled at a later period of the eruption.

4. *Note on the* Auriferous Rocks *of* South-eastern Africa. By Dr. Sutherland, Surveyor-General of Natal.

(Communicated by Sir R. I. Murchison, Bart., K.C.B.)

In communicating the chief contents of a letter which was addressed to me by Dr. Sutherland, I beg to point out to the Society that the author seems to have arrived at some of the same conclusions as those deduced by Mr. David Forbes from his examination of the gold-bearing rocks of South America, which he described as resulting from the action of two very distinct classes of igneous rocks. (See Geol. Magazine, vol. iii. pp. 385 &c., Sept. 1866).

Rod. I. Murchison.

Natal, South Africa, Sept. 8th, 1868.

A young man of the name of Parsons, who made a journey with me in March last along the southern rivers of this colony, washed some iron-sand, which gave distinct traces of gold. Since his discovery several persons have also succeeded in finding traces by the same means; but in no case has it been found in remunerative quantities; the particles never exceed the tenth or twentieth part of a grain in weight; the form is rounded and pitted, very much the same as the Australian "pepitas," or nuggets, but visible only with a magnifying power.

Parsons has been temporarily employed by the Government to explore the rivers, with a view to settle the question whether or not the metal exists in such quantities as will pay labouring men fair wages while employed in its extraction.

I have gone carefully over chap. xix. of your fourth edition of 'Siluria;' and the conclusion to which I am driven is this,—that the noble metal is in such a state of diffusion among the gneiss and granite (for these are the rocks that yield it) as to be imperceptible to the eye, and not in any way occurring in ramifications and small veins. You will recognize Humboldt's words as you give them at page 474.

In no part of the South-African promontory that I know do the hypogene rocks protrude into the Secondary formations. It is true we have a most abundant development of erupted rock, chiefly basaltic greenstone, which has pierced all the strata except the small patches of "chalk." Bain's Dicynodon-strata, which contain the coal, are abundantly impregnated with it. In one locality, the Insizwa Mountains in the basin of the St. John's River, its mineral character seems to resemble diorite; and there, along the line of contact with the Secondary strata, it contains various ores of copper, which have been found to contain about 100 grains of gold to the ton of ore. But this basaltic rock is much more recent than the basaltic rock we found in the primitive rocks; the latter appear to have settled down into perfect repose when the Palæozoic strata were undergoing a succession of invasions from eruptions of igneous matter, which in no instance assumes the type of the granitic or gneissose rocks.

There is abundant evidence that the latter rocks were very much disturbed during the period in which they were formed; for we found the gneiss in a most contorted state, and not unfrequently containing extensive developments of quartz, both in veins and in lenticular forms. None of these veins are ever found entering the strata which succeed the gneiss and granite and rest unconformably upon them. I take it that these strata are Silurian; Bain and all his Cape contemporaries thought so. They are generally horizontal, but not unfrequently are flexuous, and at times so faulty that there may be a difference of even 1000 feet in the elevation of strata which at one time were continuous on the same plane.

The primitive rocks in the valleys where the gold has been found have been very much eroded by the rivers: in some parts it is no exaggeration to take it at 3000 feet depth; and it is common to find valleys of from 500 to 1000 feet in depth. It would appear to me a reasonable assumption that no part of the gold contained in the rocks that have been removed (chiefly in the form of mud and fine sand) has been carried away, but that it remains in the alluvions now traversed by the same rivers. Although in the parent rock the quantity may be imperceptibly small, it may be found in more abundant traces in the débris, which throughout an extensive valley will show the course the river followed in the remotest periods of its existence. The features peculiar to one river will apply to all which traverse the primitive rocks; the same action has been alike effectual in all. In the faulty state of the Silurian strata to which I have alluded, there is ample proof that the primitive rocks on which they unconformably rest have suffered great displacement, and the relative levels of many localities have been greatly altered. This, no doubt, would have resulted, in the first instance, in forming valleys of elevation, upon which the denuding agency, down to the present time, has been operating. The point I wish to bring out is, that the gold contained in the primitive rocks will be found collected in the alluvions, and that hence, the amount being very small, it may be imperceptible in the rocks *in situ*, although quite perceptible in the débris along the course of the river.

I was not able to ascertain from Mauch, when he was here some months ago, whether the occurrence of the gold in the interior has the same relations as in this colony, or whether it bears comparison with that of the Ural, or Australia and America, where it would appear to pervade the ramifications of veinstones of quartz into the strata.

Discussion.

Mr. David Forbes was glad to find that Dr. Sutherland corroborated his views as to the occurrence of gold in two ways:—

1. In auriferous granite, as in Wicklow and elsewhere.
2. In eruptive diorite, a basic rock without free quartz, and certainly of postoolitic date, almost always accompanied by copper-veins. Most Californian gold-veins are connected with this class of rocks.

In constructing some of the railways of South America the granite was found to be so soft, from decomposition, that it could be cut with the pick and spade; and this softened granite, when washed, produced gold.

Prof. T. Rupert Jones considered that, by means of Dr. Sutherland's communication, the Laurentian and Silurian rocks were now, for the first time, to be recognized as existing beneath the *Dicynodon*-rocks of the Natal ridge.

February 10th, 1869.

Moreshwar A'tmárâni Tackhadakar, Esq., 3 St. George's Square, Primrose Hill, N.W., and Henry Spicer, Jun., Esq., 22, Highbury Crescent, N., were elected Fellows of the Society.

The following communications were read:—

1. *On the* Evidences *of a* Ridge *of* Lower Carboniferous Rocks *crossing the* Plain *of* Cheshire *beneath the* Trias, *and forming the boundary between the* Permian Rocks *of the* Lancashire Type *on the* North, *and those of the* Salopian Type *on the* South*. By Edward Hull, Esq. M.A., F.R.S., District Surveyor of the Geological Survey of Scotland.

It has generally been supposed that the Triassic plain of Cheshire, almost encircled as it is by coal-fields, is itself a great repository of coal-bearing strata having few or no interruptions to its continuity, except towards the southern margin, where the Triassic and Permian rocks, overlying at intervals thin and marginal representatives of the coal-measures, approach the Cambrian and Silurian districts of Shropshire. I myself for a long while held and defended this view; nor was I aware until recently that it had ever been controverted. I am informed, however, by Mr. Jukes, that in a discourse which he delivered before the British Association in Birmingham, "On the Position and Extent of Coal-measures beneath the Red Rocks of the Midland Counties," in 1865, he expressed his opinion of the probability of ridges or bosses of rocks older than the coal-measures underlying the Trias of the plain of Cheshire and Salop, and throwing the Upper Carboniferous beds into detached coal-fields. These views were illustrated by large diagrammatic sections; unfortunately no report of this lecture is published in the Transactions of the Association.

With my own mind fully imbued with the idea of a continuous sheet of coal-measures stretching beneath the New Red Marl from the southern margin of the Lancashire coal-field as far south, at least, as the Lias of Prees, near Whitchurch †, I last winter (1867) was

* Communicated with the consent of the Director General.

† In this direction the old rocks which formed the original margin of the Carboniferous basin may be expected to occur in promontories projecting northwards under the Trias and Permian beds. (See Map, p. 183.)

engaged on a memoir for the Geological Survey on the Triassic and Permian rocks of the central counties; and it was when describing and comparing the Permian rocks of Lancashire with those of Shropshire and the midland counties that I was forcibly struck by the dissimilarity in structure and composition between the beds of these two tracts of England. I had, indeed, been aware of these differences previously, having passed several years in the survey of these rocks over parts of the central counties, Shropshire and Lancashire; but until I came to compare the Permian beds of these districts with each other on the occasion referred to, I had not perceived the full force of the fact that there are two types of beds, and two only, over the whole region from Warwickshire to Lancashire and Cumberland, and that the divisional line must lie somewhere in the region of the central plain of Cheshire.

Having arrived at this conclusion, it was natural I should seek for the cause of this dissimilarity between the Permian beds on the north and the south of the plain; and there were at first sight evidently three modes of explanation.

1. In the first place, it might be supposed that the whole of the beds were deposited contemporaneously in one continous basin, and that the differences in mineral structure and composition arose from differences in the nature of the sediment brought down from opposite regions of land, and poured into the northern and southern portions of the basin respectively.

2. Or we might consider the beds of the two districts to be relatively of different ages, those of Lancashire and the north being more recent than those of Shropshire and the midland counties.

3. Or, lastly, we might suppose the beds of the two districts to be contemporaneous, but deposited in different basins, owing to the existence of a divisional ridge or barrier of the older rocks, such as is considered to have existed in the region of the Bristol Channel in the Devonian period. This is the only explanation which appears to me sufficient and tenable; and I venture to lay the reasons for this view before the Society in as concise a manner as the subject seems to admit of.

Before entering on this part of the inquiry, it will be necessary to present a brief description of the Permian rocks of the two districts, showing the distinctive characters of the two types I have referred to. But, in so doing, it is far from my intention to give a detailed description of the Permian districts of Central and Northern England, as ample accounts are already published, and to do so would therefore be but vain repetition. I shall therefore content myself with passing briefly in review the nature of the rocks as far as is necessary for my purpose, referring while so doing to the works of the eminent geologists who have written upon this branch of British geology.

Permian Beds of the Salopian Type.

Distribution.—The general characters presented by the beds of this type are those of a more or less local deposit, of which the marginal limits during deposition may in some places be traced. Towards the north-west, we first find these beds along the eastern boundary of the Denbighshire coal-field at Wrexham, and in the valley of the Dee, near Overton. South of the Severn, they reappear near Cardeston and Alberbury, where, with the remarkable calcareous breccia which there forms an important (but exceptional and local) feature*, they were originally described by Sir R. I. Murchison in the 'Silurian System.' We trace the same beds (with the omission of the calcareous rock, which disappears eastward) along the northern margin of the Le Botwood and Shrewsbury coal-fields, and again in greater force to the east of that of Coalbrook Dale. From this district they stretch southwards along the valley of the Severn, and in the district of Enville spread out over a large area, and are diversified by calcareous conglomerates and trappoid breccias, the origin of which has been referred by Professor Ramsay to the agency of ice. These beds were separated by the author in this district, as well as in that of Staffordshire, from the overlying Bunter Sandstone, and are described by Professor Ramsay in his memoir "On the Evidences of Permian Glaciers," published in the Journal of the Society †. The same beds reappear on both sides of the South Staffordshire coal-field, and are described in Mr. Jukes's memoir "On the Geology of the South Staffordshire Coal-field" ‡. Crossing the Triassic district to the east of Birmingham, they are found to emerge from beneath the Keuper Sandstone and Marl, and to occupy a large tract of country lying to the west of the Warwickshire coal-field, where these beds were surveyed by Professor Ramsay and Mr. H. H. Howell, and are described by the latter in the Memoirs of the Geological Survey, "On the Geology of the Warwickshire Coal-field."

Along the west and the south of the Leicestershire coal-field we again find these beds, but in disconnected and attenuated masses, evidently the marginal representatives of the great formation of Warwickshire. In this district is clear evidence that we have reached the original limit of the lower Permian beds towards the north-east, and that we stand on the confines of the barrier of Carboniferous rocks which divided the Permian rocks of the North of England from those of the midland counties.

Along the southern and western margin of the North Staffordshire coal-field, the lower Permian beds again appear interposed between the coal-measures and the New Red Sandstone. When traced northwards for some distance, they are lost to view at Madely, partly through the overlapping of the Bunter Sandstone, partly through attenuation. Nor do we find any representatives of the

* This calcareous breccia is only, as Sir R. Murchison shows, a local deposit, derived for the most part from the disintegration of a limestone belonging to the upper coal-measures. It cannot be considered a representative of the Permian Limestones of the North of England.

† Vol. ii. p. 185.

‡ Mem. Geol. Survey.

Permian beds referable to the Salopian type to the north of this part of England, except in the case of the little outlier at Rushton Spencer, north of Leek, where they occupy a small area, and rest directly on Lower Carboniferous beds of the Yoredale series. Their occurrence at this spot was first pointed out by Mr. E. W. Binney*, and more recently by Mr. A. H. Green in the memoirs of the Geological Survey†. Both of these geologists concur in considering the beds to be of Permian age; and their position with reference to the Lower Carboniferous strata on which they rest is a point of interest and importance as bearing on the question concerning the extent of the denudation of the Carboniferous rocks before the Permian period in this locality, coincident, as it is, with the axis of elevation, to which I shall again refer, and which forms the special subject of our inquiry.

Mineral Characters of the Salopian Type of Permian Beds.—It may, I think, be safely affirmed that over the whole tract of country above described the Permian beds belong to the *Roth-todt-liegendes* or lower stage, and are all of one type—and this notwithstanding local and exceptional interpositions of peculiar beds deriving their origin from the agency of ice (as shown by Professor Ramsay in the case of the trappoid breccias), or on account of marginal conditions, as shown by Sir R. Murchison in the case of the Cardeston brecciated rock. With these and similar exceptions, the whole series (attaining a thickness of 1500 or 2000 feet in Warwickshire) consists of an assemblage of brown, red, or purple sandstones, often calcareous, alternating with red shales and marls, and characterized by much irregularity in the stratification. Both the sandstones and the local breccias and conglomerates are distinguishable from those of the Bunter Sandstone with which they usually come in contact; and the frequent interposition of beds of red marl gives the group a *facies* differing from that of any of the divisions of the Bunter Sandstone.

Such is the character of these beds, whether we find them in Denbighshire or Shropshire on the one side, or in Warwickshire on the other. They form a group of strata of themselves, differing in their mineral characters from the Permian rocks either of the North-west or North-east of England. Their original marginal limits may at intervals be traced both in Shropshire on the west, and in Leicestershire and North Staffordshire on the east, notwithstanding the obscurity occasioned by the overspreading of the Triassic formation. The beds at Rushton Spencer form, in my opinion, a marginal outlier, deposited in a hollow, along the line of the barrier of Lower Carboniferous rocks, which originally divided the beds belonging to the Salopian type from those of the Lancashire type.

* Memoirs of the Lit. and Phil. Society of Manchester, vol. xii.

† "Geology of Stockport, Macclesfield, &c.," by E. Hull and A. H. Green. The position of these beds is shown in a section by Mr. Green in our joint paper "On the Millstone Grit of north Staffordshire &c.," Quart. Journ. Geol. Soc. vol. xx. p. 260, fig. 7.

I now pass on to trace the characters and distribution of the Permian rocks of the latter type.

Permian Beds of the Lancashire Type.

Distribution.—A fine exhibition of these beds may be observed along the banks of the Mersey, above Stockport, where they are interposed between the conglomerates of the Bunter Sandstone and the coal-measures of Cheshire. Passing towards the north and west, we find them opened out on a large scale at Collyhurst, near Manchester, where they were first identified as of Permian age by Mr. Binney*, as being clearly overlain by a series of marls with limestones containing fossils of Permian genera. From Manchester, they have been traced by the same geologist, along the southern margin of the Lancashire coal-field to Whiston, near St. Helens; and throughout they occupy a position of discordance, both as regards the Trias above and the coal-measures beneath. At Stockport the formation attains a thickness which I have estimated at 1500 feet. Whether or not it is so great, it is undoubtedly considerable; and had it not been for the superposition of the fossiliferous marls and limestones, which have been clearly determined to overlie this rock, by borings at Heaton Mersey, the whole (as far as lithological character is concerned) might have been regarded as of the Bunter Sandstone age.

Mineral Characters and Composition.—Instead of a series of interstratified sandstones, marls, breccias and conglomerates, such as that which forms the Lower Permian rocks of the Salopian type, we have in Cheshire and Lancashire a mass of homogeneous sandstone, resembling in every respect (except in position) the lowest division of the Bunter Sandstone of Shropshire and west Cheshire. This rock is generally so soft as to be used for foundry purposes, and consists of bright red and variegated sandstone, without pebbles, fine-grained, and traversed by planes of current-lamination.

When I first saw this rock in the quarry at Collyhurst, and judging only by mineral character, I thought I recognized in it the "Lower Mottled Sandstone" of the Bunter, with which I had been so familiar in Shropshire and west Cheshire; but the position of the fossiliferous marls which here overlie this sandstone, and which contain remains of the genera *Turbo, Rissoa, Natica, Gervillia, Axinus, Myoconcha,* and *Tragos,* determines beyond doubt the Permian age of the sandstone rock, as shown by Mr. Binney. It clearly forms a lower stage of the Permian formation in this part of England.

The contrast between these beds and their representatives in Shropshire and the midland counties is, in fact, as great as between the Bunter Sandstone and Permian beds of those counties.

The Upper Permian series of South Lancashire requires but short

* "On the Geology of Manchester," Trans. Geol. Soc. Manchester, vol. i.

notice here. All along the southern margin of the coal-field it consists of red calcareous marls and earthy limestones, with fossils of Permian genera, resting on the Lower Red Sandstone. At Leigh, west of Manchester, these beds have been proved by borings to reach 131 feet in thickness, with 52 courses of limestone; but their thickness in different localities is found to vary considerably, in proportion to the amount of overlapping of the Bunter Sandstone. At Stockport this overlapping is so great that the conglomerate beds of the Bunter rest directly on the Lower Permian Sandstone itself.

At Skillaw Clough, near Ormskirk, the occurrence of Magnesian Limestone in the upper member of the formation introduces a more typical feature into the succession of the beds, such as they present near Furness Abbey and Barrow Mouth, as described by Mr. Binney*, and enables us to recognize in them the representatives of the great calcareous formation of Durham, Yorkshire, and Notts. Mr. Kirkby, on palæontological evidence, refers the upper member of the Permian series in South Lancashire to the "Lower Limestone" of Yorkshire†.

In the "Lower Sandstones" of Penrith, estimated by Professor Harkness to attain a thickness of 5000 feet‡, we have the apparent representative of the Lower Permian Sandstone of south Lancashire, but more fully developed in a northerly direction, as is usually the the case with sandstone rocks of the Triassic and Permian ages in this part of England.

Durham, Yorkshire, and Nottinghamshire.—It is not within the scope of this paper to refer to the Permian formation of the North-east of England, except to point out the relationship of this series of beds to those of the midland counties and Lancashire, as far as regards original deposition. I will therefore only remark that, as regards their relations to the Lancashire series, though so different in mineral character, they really belong to the same type. Here we have the development of the calcareous member on the one hand, and of the sedimentary member on the other, being an illustration of the law of development, in opposite directions, of calcareous and sedimentary strata, which I believe may be observed in the case of all natural groups of rocks. And as it has been shown in a former paper that the elevation of the Carboniferous rocks along the meridional axis of the Pennine chain has taken place since the Permian period, there is every reason to suppose that the Permian beds, both on the North-west and North-east of England, were deposited within the limits of the same hydrographical basin, and that there was a gradual variation of mineral character taking place across the North of England. This view seems to be held by Mr. Kirkby with reference to the Upper Permian series§ in both districts.

* Mem. Lit. and Phil. Soc. Manchester, vol. xii. pp. 45, 46.

† Quart. Journ. Geol. Soc. vol. xvii. p. 320.

‡ *Ibid.* vol. xviii. p. 210.

§ Quart. Journ. Geol. Soc. vol. xvii. p. 321. Mr. Kirkby remarks, "The fauna of the Lancashire area appears to have existed on the argillaceous and semical-

On the other hand, the evidence which I am about to adduce seems to show that the Permian rocks both of the North-west and North-east of England were disconnected during their deposition from those of the midland counties and Shropshire. Under this view, it will be apparent that there are in reality only two types of Permian beds in England, those of the north and those of the midland counties; though at first sight it might have been supposed there were three, namely, those of the Salopian, Lancashire, and Durham or Yorkshire types.

Possible Causes of the typical differences in the Permian formations over the Salopian and Lancashire Areas.

Having thus described the distinctive characters and range of the two types of Permian beds in the tract of country under investigation, it now remains to inquire into the causes of this diversity of character. As already stated, there appear to be three possible modes of explanation.

1. We might suppose that the beds of both types had been deposited in the same basin, and that the differences in mineral and stratigraphical character were due to differences in the sources of the sediment. This explanation appears to me insufficient, as there are no intercalations on either side. Considering the great thickness which this rock attains in North-east Cheshire (at least 1500 feet), and the proximity of the two districts, it is strange that it should not be represented by interstratification amongst the beds of North Staffordshire, if the two areas were in communication, or, on the other hand, that the beds of the Salopian type should not be represented by interstratification amongst those of the Stockport and Manchester district. This explanation also fails to account for the absence of the Upper Permian beds of Lancashire in the southern area, a series of beds which, from their very nature, may be presumed to have extended as far as the hydrographical boundaries would admit.

2. To suppose that the two types of rocks were not contemporaneous is still more unsatisfactory, and is not in accordance with the relations which the beds in both regions bear to the Carboniferous rocks on which they repose. These relations are precisely similar. In some places there is (as it were by accident) conformity, in others, great discordance. To suppose that there are two types of *Roth-todt-liegende* representing two successive stages of this earliest period of the Permian group, is not in accordance with observation in other districts. On the contrary, the beds of the Salopian type must, I think, be regarded as representatives in time of the Lower Red Sandstone of Lancashire, and both as representatives of the Lower Permian stage, or *Roth-todt-liegende* of Germany.

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careous submarine mud-flats that lay off the coast of a Permian land-area; the Yorkshire fauna certainly existed further away in deeper water, and within the limits of regular deposition of calcareous sediment."

3. *Dividing ridge of Lower Carboniferous Rocks* (see fig. 2). I now come to the explanation which seems to me the most probable, and one which is borne out by an examination of the physical geology of the North of England,—namely, *the existence of a concealed ridge, or barrier, of Lower Carboniferous rocks, dividing the hydrographical areas belonging to the Lancastrian and Salopian types respectively, and the consequent deposition of the contemporaneous beds in two separate basins.*

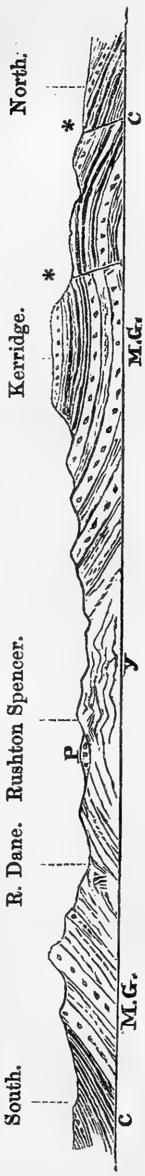


Fig. 1.—*Section across the Anticlinal of the River Dane, near Congleton.*

P. Permian outlier of Rushton Spencer.
C. Coal-fields of North Staffordshire on the south, and of Cheshire on the north.
M.G. Millstone Grit series.
Y. Yoredale series.
* *. Faults.

In a recent communication to this Society* I have shown that at the close of the Carboniferous period the Carboniferous beds of Lancashire were thrown into a series of folds, the axes of which range nearly east and west, and are parallel to, and continuous with, those which influence the same beds in Yorkshire as they approach and are lost beneath the Magnesian Limestone, as originally pointed out by Professor Phillips. This system of disturbances I ventured to call "the Pendle System," because it is well illustrated by the direction and flexures of the Pendle range of hills, running in an east-north-east direction. I also showed that there was a nearly parallel line of upheaval to the south of this range, passing along the valley of Rossendale, the direction of which is very nearly east and west; and to this I applied the term "Rossendale anticlinal."

When we proceed further south into the main coal-field of South Lancashire, we have no evidence of a repetition of these foldings (except, perhaps, as represented by a few east-and-west faults); but when, following the line of the Carboniferous rocks along the margin of the plain of Cheshire, we arrive in the district bordering the valley of the river Dane, near Congleton—we again have evidence of a very powerful line of upheaval lying to the northward of Congleton Edge, and dividing the Cheshire coal-field from that of North Staffordshire. The general arrangement of the beds here will be better understood from the accompanying section, in which minor details are omitted (see fig. 1). The section is drawn from north to south in a line nearly parallel to the "Red-

* "On the Relative Ages of the Lading Physical Features and Lines of Elevation of the Carboniferous District of Lancashire and Yorkshire," Quart. Journ. Geol. Soc. vol. xxiv. p. 323.

rock fault," along which the Triassic rocks are brought in on the west.

It will be observed that along this anticlinal the lower beds of the Yoredale group, immediately overlying the Mountain Limestone, are brought to the surface, this latter rock itself being found at Astbury, at the base of Congleton Edge, but not in the line of the section*.

As regards the age of this anticlinal, we are, fortunately for our purpose, not left in doubt. Not far to the eastward is the Permian outlier of Hug Bridge, near Rushton Spencer, where, as already stated, sandstones and marls of Permian age rest immediately on the Yoredale beds. We have here, therefore, an illustration, similar to that of Clitheroe, in North Lancashire, of disturbances accompanied by enormous denudation of the Carboniferous rocks at the close of the Carboniferous period, and antecedently to that of the Permian. The amount of denudation in this instance may be thus estimated† :—

		feet.
Coal-measures	Upper	1000
	Middle	4000
	Lower	1000
Millstone Grit	Several divisions	1000
Yoredale Series (in part).	Several divisions	2000
		9000

The easterly prolongation of the anticlinal of the river Dane cannot be very clearly traced, owing to the rearrangement of the Carboniferous beds along the lines of disturbance in a meridional direction (north to south) at the close of the Permian period. As already shown on a former occasion ‡, the series of foldings along axes ranging from west to east into which the Carboniferous rocks of the North of England were thrown at the close of the Carboniferous period have been modified by two subsequent lines of disturbance at the close of the Permian and Jurassic periods respectively; but the whole three systems bear a close physical relationship in time and direction to each other. In the district bordering the Mountain Limestone of Derbyshire the intersection of these lines of disturbance, accompanied and followed, as they have been, by several denudations, have complicated the structure of the rocks as it originally existed at the beginning of the Permian period. Hence the difficulty of following out the course of the anticlinal of the Dane eastward; nevertheless it may, I think, evidently be traced

* A detailed description of the beds in this district will be found in "The Geology of the Country around Stockport," &c., by Messrs. Hull and Green. Mem. Geol. Survey, pp. 69–74.

† The thickness of the Coal-measures is that ascertained by the Geological Survey as applying to North Staffordshire, which is less than that of Lancashire. The thickness of the Millstone Grit and Yoredale beds is that given in the Memoir, on "the Geology of Macclesfield," &c., above quoted (see p. 85). The above estimates are probably rather under than over the truth.

‡ "On the relative Ages of the Physical Features," &c., *suprà cit.*

along the course of the Yoredale beds to the north of the Cheadle coal-field, and across the Mountain-Limestone country by Meerbrook and Butterton, in the direction of Matlock, while a branch stretched more to the southward in the direction of Charnwood Forest.

I cannot, therefore, but regard the anticlinal fold which separates the coal-fields of North Staffordshire and Cheadle on the south from those of Poynton and Goldsitch Moss on the north as belonging to the Pendle system of disturbances, ranging nearly from west to east, and, by the position of the Permian beds at Rushton Spencer, clearly shown to have originated at the close of the Carboniferous period. If such be the case, can it be doubted that the anticlinal extends *westward* under the Triassic rocks of Cheshire?

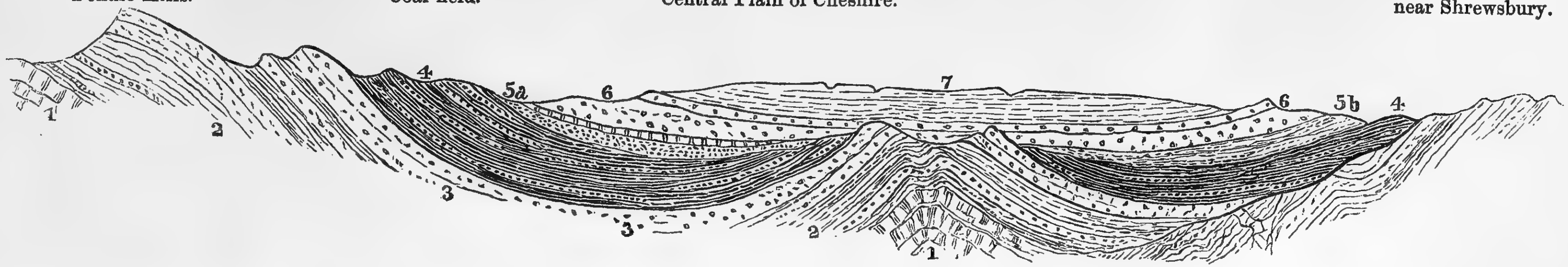
If, therefore, as appears to be the case, the Dane anticlinal stretches westward under the Triassic plain, we may reasonably look for some evidence of its continuance and reappearance on the western margin of the plain where the Carboniferous beds emerge from beneath the New Red Sandstone. This evidence, I think, we can find.

The Carboniferous Anticlinal in North Wales.—If the Geological Map be referred to, it will be observed that at its southern extremity the Flintshire coal-field is completely dissevered from that of Denbighshire by the uprising of the Lower Carboniferous rocks, from which the coal-measures have been denuded.

The age of this fault, belonging probably to several periods of vertical movement, is, at least, clearly præ-Triassic, as it disappears beneath the New Red Sandstone near Hope without producing any displacement of the beds; and it is also post-Carboniferous. Its relation to the Permian beds cannot be determined by observation, as it is nowhere brought into contact with them. It seems, indeed, to be gradually dying out towards the east as it approaches the New Red Sandstone, and to pass into an anticlinal axis. The view which I venture to offer is this:—I regard this upheaval as belonging to the Pendle system of disturbances at the close of the Carboniferous period, as indicated by the parallelism of its direction to this system, and also as being continuous in direction with the Dane anticlinal axis on the eastern borders of the Cheshire plain.

Supposed Structure of the Carboniferous Rocks under the Cheshire Plain.—If the above reasoning be admitted, it follows that there exists under the Triassic rocks of Cheshire an axis of elevation of Lower Carboniferous beds ranging from the southern borders of the Flintshire coal-field near Hope, on the west, to the valley of the Dane, north of Congleton, on the east, dividing the coal-field, which we may conclude originally spread uninterruptedly over the whole area, into two portions, to the north and south of this axis. I do not pretend to much precision in describing the course and structure of this axis under a tract of newer rocks 35 miles in width: it is probably accompanied by more than one parallel folding of the beds; but I think, with the arrangement of the rocks at Congleton Edge and the Roaches near Leek before us, we might venture to idealize the structure of this axis and its relations to the newer formations

Fig. 2.—*Diagrammatic Section, to illustrate the position of the supposed axis of elevation, and its relations to the Triassic and Permian Rocks under the Plain of Cheshire. (Details omitted.)*



1. Carboniferous Limestone near Clitheroe, and along the axis of the supposed ridge under the Cheshire Plain.
2. Yoredale series, cropping out along the flanks of the Pendle Range, and, along with the Millstone Grit, becoming attenuated southwards, and terminating against the shelving flanks of the Silurian rocks in Shropshire (on the right-hand side of the woodcut).
3. Millstone-Grit series.
4. Coal-measures of the South-Lancashire Coal-field, dipping under the Permian and Triassic rocks of Cheshire, then flattening and rising towards the south, and dissevered from the Coal-measures of Shropshire by the supposed axis of elevation.

5 *a.* Permian series of the Lancashire type, resting discordantly on the Carboniferous rocks, consisting of red marls with limestone in the upper series, and of soft red sandstone in the lower.

5 *b.* Permian series of the Salopian type, separated from the Lancashire beds by the ridges of Carboniferous rocks, and consisting of purple sandstones and marls, breccia and conglomerates, &c.

6. Bunter Sandstone, becoming thinner towards the south and on approaching the Palæozoic axis.
7. Keuper Marls and Sandstone of the Central Plain of Cheshire.

O 2

somewhat as shown in the accompanying section (fig. 2 ; see also map, page 183).

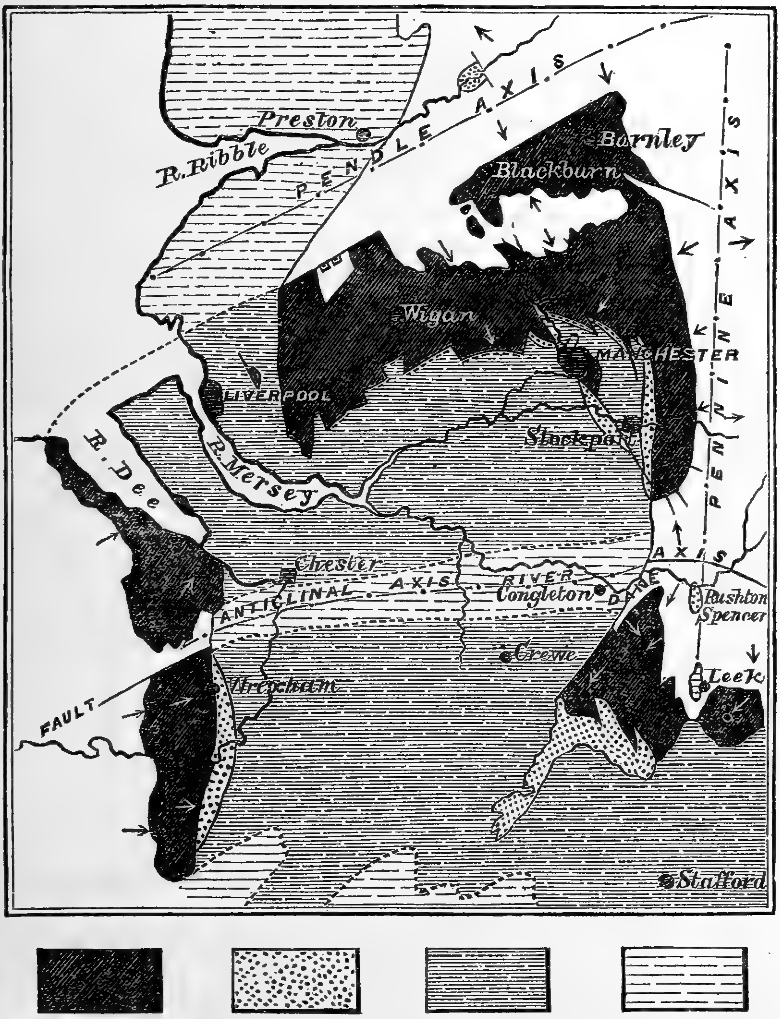
The Coal-measures on each side of the supposed Axis.—As there is no evidence of any similar axis, we may suppose that the coal-field extends from the northern flank of the Cheshire axis to the borders of the Lancashire Coal-field on the north, which, with that of Flintshire on the west and Poynton on the east, must form one continuous sheet (see map). To the south of the axis the coal-measures may also be supposed to stretch for a considerable distance, and to be continuous with those of Denbighshire and North Staffordshire. The southern limits of this coal-tract are in all probability very irregular and indented, owing to the proximity of the ancient margin of the Carboniferous area. Should the plains of Mid-Cheshire ever be pierced in search of coal, which from the enormous thickness of the overlying secondary rocks appears hopeless, care will be required to avoid striking upon the rocks below the coal, in the line of the anticlinal axis and along the southern margin, indicated by the lighter shading on the map.

The Permian Beds on each side of the supposed Axis.—The existence of such an axis of elevation as is here indicated, formed at the close of the Carboniferous period, and belonging to the "Pendle system" of flexures, serves, I think, to explain the difference in the character of the Permian formation to the north and to the south of such a line in a more satisfactory manner than any other hypothesis. The elevation of the Lower Carboniferous rocks into ridges, from which the coal-measures were swept away partly by atmospheric, partly by marine, denudation, would produce a ridge, or ridges, of land-surface dividing the Permian basin on the north from that on the south. That the Carboniferous rocks *were* thrown into such ridges flanking the Permian sea, is clear from the position of the beds at the northern base of the Pendle range at Clitheroe. To admit of this hypothesis, we are not required to adopt a speculation which has no example in this part of the country; while it helps to solve the problem why the Permian beds on either side of this ridge belong to two distinct types, the Salopian and the Lancastrian.

Conclusion.

In conclusion, I regard the axis under the Cheshire plain as merely the prolongation of the Carboniferous barrier which separated the Permian basin of the north of England from that of the Midland counties and Shropshire. The barrier was apparently prolonged towards the district of Charnwood Forest, where it was composed of Cambrian rocks, and was formed for the most part of Mountain Limestone, Yoredale beds, and Millstone Grit, on either side of the barrier. The Permian formation itself gives evidence of the proximity of land; for on the north side the Magnesian Limestone becomes deteriorated both in composition and thickness towards Nottingham, and on the other the Permian beds along the skirts of the Leicestershire Coal-field are evidently marginal representatives of the great formation of Warwickshire. To the north and to the south of this barrier the Permian formation exists under two distinct phases or types of character; and the occurrence of such a dividing ridge as I have indicated seems to offer the most satisfactory explanation of these differences in composition and arrangement.

Fig. 3.—*Sketch Map of part of Lancashire, Cheshire, and Shropshire, showing the position of the concealed ridge of Lower Carboniferous Rock, or anticlinal axis, and of the Coal-measures to the north and south of the axis. By Edward Hull, F.R.S.*



Coal-measures at the surface. — Permian Beds. — Triassic Beds overlying Coal-measures. — Triassic Beds resting on strata older than the productive Coal-measures.

EXPLANATION OF MAP.

This Map is intended to show the position of the existing Coal-fields round the margin of the Triassic plain of Cheshire, and the extension of the Coal-measures below the Triassic and Permian rocks of the plain. The position of the axis of Lower Carboniferous rocks from west to east is represented by the unshaded band ranging under the banded portion (representing the Trias and Permian area), and emerging at each side in the tract now formed of Lower Carboniferous beds in North Wales and East Cheshire. The shaded portion banded with close lines shows the extent of the Coal-measures to the north and south of the axis covered by Permian and Triassic formations; and it will be observed that the whole Coal-tract, both at the surface and concealed, resolves itself into two great coal-fields to the north and to the south of the supposed barrier of Lower Carboniferous rocks, that to the north being continuous with the Coal-fields of Flintshire, Lancashire, and Cheshire, that to the south with the Coal-fields of Denbighshire and North Staffordshire. A southerly prolongation of this tract probably connects it with the Shrewsbury Coal-field.

It will be observed that at the northern part of the map, and extending inland for some distance from the coast of Lancashire, there is a large banded tract of ground covered by Triassic rocks, under which, if penetrated, I consider that only the Lower Carboniferous beds (below the coal) would be found, the whole of the Coal-measures having been removed by denudation before the Permian period. To this tract I have referred in my paper on the relative ages of the physical features and lines of elevation of Lancashire (Quart. Journ. Geol. Soc. vol. xxiv. p. 333).

Discussion.

Prof. Ramsay considered that the lithological differences in the Permian rocks of the two areas referred to were hardly so great as was supposed by Mr. Hull.

Mr. Prestwich remarked that the nearly equal thickness of the Permian deposits in the two areas was in favour of their having been deposited in continuity.

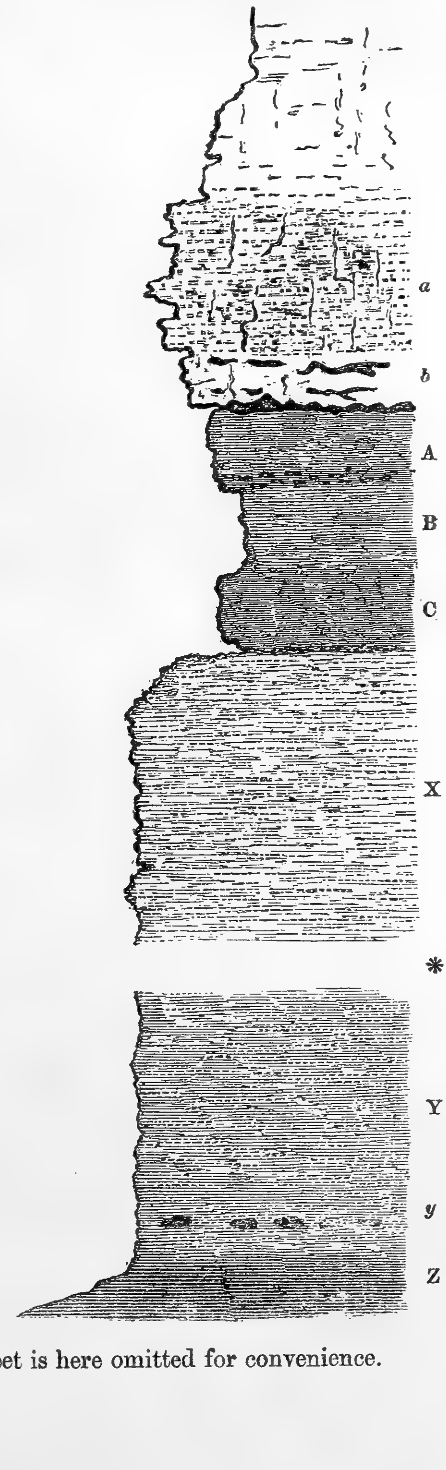
Mr. W. W. Smyth considered that the difference between the Permian beds in question was not so great as the author supposed, but that the undoubted existence south of Chester of a breadth of 5 or 6 miles of Bunter Sandstone lying immediately upon the Millstone Grit, although observed only at one point, was strongly in favour of the author's hypothesis.

Mr. Hull stated in reply that the difference between the two groups of Permian rocks to which he had referred was so great as to render their identity at first sight very doubtful. The extent of the anticlinal at Rushton Spencer is so great that it must be inferred to have extended far both to the east and west.

2. *On the* Red Chalk *of* Hunstanton. By the Rev. T. Wiltshire, M.A., F.L.S., F.G.S.

Not far from the apex of the angle which the Wash, opening out into the German Ocean, forms on the western coast of Norfolk, is situated a cliff of about a mile in length and 50 or 60 feet in height, on which, at its greatest elevation, is erected the Hunstanton Lighthouse. This headland, which gradually rises from the low ground on the north, and finally sinks towards the south through the effect of local denudation, is remarkable, even when viewed from a distance, from the circumstance that its face is marked by three parallel coloured bands, slightly inclined, and cropping out in succession on the surface soil, of which bands the uppermost is white, the next bright red, and the lowest yellow, each division being sharply defined, without any intermingling of tints at the lines of contact. A close inspection shows that the highest stratum, the white, consists of a hard calcareous substance, compact in texture, and much shattered and fissured, originally deposited in such a manner that its materials were arranged in definite layers, two of which (*a*, *b*), those forming the base, are represented in the annexed section drawn to scale. The first of these (*a*), in thickness about 2 feet 6 inches, is noticeable for the presence of an enormous quantity of fragments of *Inocerami* dispersed throughout its whole extent, and which under the influence of weathering impart to this portion of the cliff a jagged and rough appearance. Its characteristic fossils are spines of *Cidaris vesiculosa, Holaster planus, Vermicularia umbonata, Terebratulina*

Section of Hunstanton Cliff.



* A thickness of upwards of 30 feet is here omitted for convenience.

gracilis, Terebratula semiglobosa, and *Plicatula inflata*. The band *b*, in thickness about 1 foot 2 inches, is conspicuous for a meandering and many-branched sponge, *Siphonia paradoxica*, specimens of which are visible in the cliff only in short lengths, but on the fallen blocks washed by the sea are seen to extend continuously and horizontally over many square feet of surface. The underside of *b* departs from the general arrangement in the other courses; for its base, instead of forming a flat or approximately flat floor, is broken up into a series of irregularly rounded ridges and hollows, which undulate perpendicularly within the limits of a few inches, and are represented in the section. The fossils from this bed, *b*, are not so many (numerically speaking) as those in *a*; the chief forms are *Siphonia paradoxica, Terebratula biplicata, Terebratula semiglobosa*, var. *undata, Kingena lima, Avicula gryphæoides*, and *Inoceramus latus*.

Next in succession, in descending order, is the red stratum, locally called the "Red Chalk," marked by an abundance of organic remains, some of which, as *Bourgueticrinus rugosus* and *Terebratula capillata*, are, in England, special to this deposit. Lithologically, it is unlike the beds above it from the fact of its abounding in great numbers of rolled and subangular pebbles of quartz, slate, &c., which for the most part are of small size and insignificant, though occasionally assuming larger dimensions. In appearance it is divisible into three almost equal portions, of which the first (A) has towards its base a large quantity of fragments of *Inocerami*, the second and thickest division (B) is rich in *Belemnites*, and the third and lowest (C) yields many *Terebratulæ*. The bands A and B are exceedingly hard and stony, and sufficiently tabular in character to have offered a plane of resistance to former upheaving forces, and to have afforded great support to the overlying white beds; thus, although the whole cliff was evidently, in ancient geological times, much disturbed, the perpendicular fissures, which rise out of the yellow bands (X, Y), cease just before reaching the layer B, affect the red beds to the right and left of the points of application, and then start upwards through the white stratum in new positions and in greater number. The colouring-matter in A is less equally distributed than in B and C, and seems to have been accumulated as an envelope around irregular spheroidal masses; in B the tint is of a lighter, and in C of a darker shade than in the highest division. The middle bed (B) is in substance the hardest and most homogeneous of the three; the last (C) is the least compact. Viewed in the cliff, A wears a mottled aspect, B a nodular facies, and C a plane surface. Towards the base of the bottom bed (C) the hard limestone character of the Red Chalk is lost, and the stratum degenerates into a somewhat sandy incoherent mass, hardly differing from the underlying yellow division except in colour. On account of the less compact nature of the last of the three red beds, fossils are more easily procured from it, have their surfaces in better condition, and are more readily seen when of small size. Resting on the top of A and filling the undulations on the underside of the lowest white bed (*b*), is a bright red argillaceous substance, very friable, without sand, apparently destitute of organic remains, and never exceeding two or three inches in thickness.

The fossils in the three red beds are for the most part similar, and suggest the inference that all three bands may be considered as forming a single division and composing one geological stratum. In the case where certain fossils have been seen only in the lowest part, their absence elsewhere may be accounted for on the ground that the upper bed (A) is less numerically abundant in organic remains than are those below, and that the middle bed (B) is so exceedingly hard and compact as to diminish the chance of discovering fossils. *Avicula gryphœoides* and *Spongia paradoxica* would seem, however, to be special to the upper part of A, the highest of the three red beds. The dip of these beds in the cliff is about 2°, to the north; sections inland taken at right angles give the same number of degrees to the east.

Many visits to the Hunstanton Cliff, undertaken at intervals during the last ten years, have enabled me to gather together a very fair collection of the species peculiar to the red beds. The following list, taken from specimens in my cabinet, may therefore be regarded as representing the general fauna of the "Red Chalk." From this list are purposely excluded doubtful species and mere varieties of form, those only being introduced which can be safely defined. As a matter of interest, the numerical frequency of the fossils and their position in the three divisions are recorded. The letters *v. c.*, *c.*, *r.*, *v. r.*, in the fourth column stand for very common, common, rare, and very rare, and imply the relative abundance of the various species. The mark * in one or more of the first three columns shows that the fossils to which it is affixed have been met with in such bed or beds.

Fossils from the Red Chalk.

	Highest Band, A.	Middle Band, B.	Lowest Band, C.	Frequency.
Spongia paradoxica, *Webster*	*	..	..	c.
Scyphia tenuis, *Rœmer*	*	*	..	r.
Berenicea regularis, *D'Orb.*	..	*	..	c.
Proboscina dilatata, *D'Orb.*	..	..	*	r.
Reptomulticava mamilla, *Reuss*	..	*	*	c.
Stomatopora longiscuta, *D'Orb.*	..	..	*	r.
Micrabacia coronula, *Goldf.*	..	*	*	c.
Cyclolites polymorpha, *Goldf.*	..	*	*	c.
Podoseris mamilliformis, *Duncan*	*	*	*	c.
—— elongata, *Duncan*	..	*	..	r.
Bourgueticrinus rugosus, *Ag.*	*	*	*	c.
Torynocrinus canon, *Seeley*	..	*	..	c.
Pentacrinus Fittoni, *Aust.*	..	*	*	c.
Cidaris gaultina, *Forbes*	..	*	*	r.
——, n. s., spines, *Wright* (*Cret. Echin.*, pl. xii. fig. 8)	..	..	*	v. r.
Pseudodiadema Brongniarti, *Ag.*	..	*	*	r.

	Highest Band, A.	Middle Band, B.	Lowest Band, C.	Frequency.
Pseudodiadema ornatum, *Goldf.*	..	*	*	r.
Salenia Wiltshirei, *Seeley*	..	*	*	r.
Holaster suborbicularis, *Ag.*	..	*	*	c.
Serpula antiquata, *Sow.*	..	*	*	r.
—— cristata, *Duj.*	..	..	*	r.
—— depressa, *Goldf.*	..	..	*	r.
—— rustica, *Sow.*	..	*	..	r.
Vermicularia umbonata, *Mant.*	..	*	..	c.
Pollicipes unguis, *J. Sow.*	..	..	*	v. r.
Terebratula biplicata, *Broc.*	*	*	*	v. c.
—— capillata, *D'Arch.*	*	*	*	c.
—— semiglobosa, *Sow.*	*	..	*	r.
Terebratulina gracilis, *Schl.*	*	..	*	r.
Kingena lima, *Defr.*	*	*	*	r.
Rhynchonella sulcata, *Park.*	..	*	*	r.
Avicula gryphæoides, *J. Sow.*	*	..	..	c.
Exogyra conica, *Sow.*	..	*	*	r.
—— haliotoidea, *Sow.*	..	*	..	r.
—— laciniata, *Nils.*	..	*	..	r.
—— Rauliniana, *D'Orb.*	..	*	..	r.
Inoceramus Crispii, *Mant.*	*	*	..	c.
—— sulcatus, *Sow.*	..	*	..	r.
—— subsulcatus, *mihi* (*Pictet et Roux, Grès Verts*, pl. 42. fig. 1*d*)	..	*	..	r.
—— tenuis, *Mant.*	..	*	..	c.
Lima globosa, *J. Sow.*	..	*	..	r.
—— Iteriana, *Pictet et Roux*	..	*	..	v. r.
Ostrea Normaniana, *D'Orb.*	..	*	*	c.
—— vesicularis, *Lamk.*	..	..	*	c.
Pecten Beaveri, *Sow.*	..	*	..	r.
Plicatula pectinoides, *Sow.*	..	..	*	r.
Spondylus striatus, *Sow.*	..	*	*	c.
Cerithium mosense, *Buv.*	..	..	*	v. r.
Pleurotomaria, cast of	..	*	..	r.
Nautilus albensis, *D'Orb.*	..	*	..	r.
—— Bouchardianus, *D'Orb.*	..	*	*	r.
Ammonites auritus, *Sow.*	..	*	*	c.
—— Beudanti, *Brong.*	..	*	..	r.
—— lautus, *Sow.*	..	*	..	c.
—— rostratus, *Sow.*	..	*	..	r.
Belemnites attenuatus, *Sow.*	*	..	*	v. c.
—— minimus, *List.*	*	*	*	v. c.
—— ultimus, *D'Orb.*	*	*	*	v. c.
Ischiodon	..	*	..	r.
Otodus appendiculatus, *Ag.*	*	*	*	r.
Plesiosaurus latispinus, *Owen* (?) ..	*	*		

Underlying the Red Chalk is a coarse sandy deposit (X, Y of the Section) termed in the district "Carstone," of a yellow tint, loose in composition and full of small pebbles, which are subangular and polished. The upper part (X), for about 8 feet, consists of much sand, and is succeeded by a dark-brown stratum (Y), in which, at the beginning, the pebbles are of larger size, and in which, afterwards, the sandy particles are so loosely held together as to present a strong contrast to the massive nature of the white and red beds above. Covered by the Carstone and adjoining it is a bed of clay marked Z in the section.

Throughout the space of more than 30 feet below the base of the Red Chalk no fossils have been hitherto found at Hunstanton in the Carstone, but beyond that distance, and just above the clay (Z), there is a line of nodules (*y*) in which are numerous specimens of *Ammonites Deshayesi,* and occasionally of *A. Cornuelianus*; close to these nodules are others of ironstone, very similar to the masses found in the Lower Greensand of Blackgang and Shanklin, in the Isle of Wight, containing casts of fossils, of which I give the following list, the species having been determined by Mr. Etheridge.

Fossils from Nodules in base of Carstone.

Wood.	Pecten orbicularis, *Sow.*
Trigonia, sp.	Cardium subhillanum, *Leym.*
Leda, sp.	Pleurotomaria gigantea.
Pecten striato-punctatus, *Rœmer.*	Ammonites Cornuelianus, *D' Orb.*
Lucina crassa, *Sow.*	Dentalium.
Isocardia angulata, *Phil.*	Pectunculus.
Nucula planata, *Desh.*	Terebratula biplicata, *Broc.*
Avicula macroptera.	Dianchora.

From this part of the Carstone I have obtained *Perna Mulleti, Ancyloceras gigas, Pleurotomaria*—fossils which, viewed in connexion with the presence of *Ammonites Deshayesi,* &c., correlate the portion of the Carstone immediately above the Clay (Z) with the base of the English Lower Greensand.

By a reference to the section it will be seen that the Hunstanton Red Chalk is, in position, lower than the Chalk Marl (*a*) and higher than the Lower Greensand (X, Y); the fossils also, it will be observed, recorded in the list as common to the bed, present a mixture of what are generally considered Lower Chalk, Upper Greensand, and Gault forms. The mingling together of these species, no less than the peculiar aspect of the stratum, has long caused the Red Chalk to be a fertile field for discussion in reference to its proper position in the geological scale, various writers offering various opinions, Mr. C. B. Rose* inclining to its being the equivalent of the Gault, Mr. H. Seeley† to its being Upper Greensand, and Mr. Judd‡ to its combining both formations. If, however, the very fine section of the Gault at Folkestone (where the succession of the beds and their fossils can be examined *in situ*) be taken as typical of the English Gault, then it will become evident that the "Red Chalk" is the representative of the upper division of that formation; for at

* "On the Geology of West Norfolk," Phil. Mag. 1835, vol. vii. p. 180.

† "Notice of Opinions on the Stratigraphical Position of the Red Limestone," Ann. Mag. Nat. Hist. 1861, vol. vii. p. 240.

‡ "Strata which form the base of the Lincolnshire Wolds," Quart. Journ. Geol. Soc. vol. xxii. p. 249, 1867.

Folkestone, in the limits between 30 feet and 70 feet above the top of the Lower Greensand, and still at some distance beneath the Upper Greensand, can be found all the Ammonites and Nautili given in the previous list, together with the Belemnites and the whole of the other species mentioned as peculiar to the Red Chalk, excepting only the Amorphozoa, the Corals, *Bourgueticrinus rugosus*, *Toryno-crynus canon*, *Pseudodiadema Brongniarti*, *P. ornatum*, *Salenia Wiltshirei*, *Holaster suborbicularis*, *Serpula cristata*, *S. rustica*, *Te-rebratula capillata*, *Rhynchonella sulcata*, and *Spondylus striatus*. The presence of the varietal form of *Inoceramus sulcatus* (which I have ventured to name *subsulcatus*) and the extreme rarity or total absence of *Inoceramus concentricus* are marked features in the upper part of the Gault at Folkestone, define a particular zone, and correspond with what is observed at Hunstanton. That a few species may not be common to both localities is to be expected, seeing that the two places are 150 miles apart, and that the strata must have been deposited at those spots under somewhat different conditions, and in a manner which might not be equally favourable to certain forms of life.

According to the statements of persons resident in the district adjoining Hunstanton, and who have seen inland sections opened for agricultural purposes, the blue Gault with its characteristic Belemnites rests on the Carstone at Flitcham, 10 miles south of Hunstanton, but rather nearer the latter place, and still close to Flitcham, a red clay occurs immediately under the white chalk, thus connecting the Blue Gault with the "Red Chalk." From Sandringham, 8 miles south of Hunstanton, the outcrop of the Red Chalk can be traced without difficulty and continuously to its last appearance on the surface of the ground near the Lighthouse.

The lithological difference between the Red Chalk with its stony hardness and accompanying minute pebbles, and the Blue Gault with its soft clay, is no argument against the two being geologically equivalent; for as great a dissimilarity exists in the Carstone. At Hunstanton the Carstone stratum is dark yellow and very full of pebbles; at Sandringham, at the corresponding portion, it is a pure white sand. But the evidence which organic remains and local position supply in favour of the Red Chalk being a northern equivalent of the Gault of Kent is singularly strengthened by testimony of quite another kind. Chemical analysis shows that the strong contrast in colour which exists in the case of the Red Chalk and the Gault, and which apparently places them apart, is a combining link between them, the upper part of the Kentish Gault being as ferruginous (only under another aspect) as the Red Chalk itself. This fact, for which I am indebted to Mr. David Forbes, is described in the following extract from a letter written by that gentleman to myself, referring to a comparative chemical analysis of the Gault and Red Chalk, the part of the Gault selected for the experiment having been taken from the Folkestone beds, about 50 or 60 feet above the top of the Lower Greensand, where, for some vertical distance, the deposit is very homogeneous.

"The specimen of Gault," Mr. Forbes writes, "is, properly speaking, a marl (not a clay), being a mixture of ferruginous clay with a considerable quantity of carbonate of lime. The iron contained in it is all in the state of protoxide, amounting to 5·96 per cent., which would be equivalent to 6·606 per cent. of sesquioxide (red oxide) of iron, or to 4·62 per cent. metallic iron. The Hunstanton Red Chalk contains more carbonate of lime and much less clay than the above; and all the iron it contains is in the state of sesquioxide (red oxide), which amounts to 5·96 per cent., or is equivalent to 5·28 per cent. of protoxide of iron, or 4·10 metallic iron in the substance; it consequently, notwithstanding its red, or what generally would be termed ferruginous appearance, in reality does not contain quite as much iron as the Gault does, which has no such aspect; there seems to be no objection, from a chemico-geological point of view, why these rocks may not be representatives of one another. If the Gault were subjected to any oxidizing influences it would assume the red colour of the Hunstanton rocks, as it does also by burning."

Summing up, therefore, the evidence brought forward, observing that the fossils of the Red Chalk agree for the most part with those from the upper portion of the Gault of Folkestone, that the red band of Hunstanton agrees in position with the Norfolk Gault as being below the Chalk and above the Carstone, that the presence of iron brings it into concord with the Gault of Kent, it would appear that the Red Chalk is the representative of the upper portion of the typical English Gault (as seen in the Folkestone Section), and not of the Upper Greensand.

If the Upper Greensand exist in the Hunstanton series, its place must be in the band *b*, which rests on the Red Chalk, and which is so abundantly stored with *Spongia paradoxica* and *Avicula gryphæoides*.

Discussion.

The President remarked that the vertebræ from the Red Chalk, noticed and exhibited by Mr. Wiltshire, were undoubtedly those of *Plesiosaurus latispinus* of the Upper Greensand; but associated with these were other bones which he could not identify with any part of the skeleton of *Plesiosaurus*.

Mr. Etheridge spoke in confirmation of the author's views, referring especially to the Palæontological evidence.

Mr. S. Hughes mentioned a boring near Hitchin where a hard sandstone, resembling Carstone, was found immediately below the Gault, the latter having a thickness of 280 feet.

Mr. David Forbes remarked on the similarity in the amount of iron present in rocks so dissimilar as the Red Chalk and the blue clay of the Gault.

Prof. Morris noticed the similarity of the Carstone of Hunstanton, and its equivalent beds, to the Hilsthon and Hilsconglomerat, especially in their containing abundance of pisolitic iron-ore. He then adverted to the marked difference of the Lower Greensand of the

Midland districts from that of the southern and northern areas in England, in which that formation is developed,—the southern exhibiting the entire series of deposits, which seem to reappear in the northern area, while in the Midland district the lower members have not been observed.

Mr. Judd remarked that the conditions of deposition in the North and South had been different; the Red Chalk increases northwards, from 4 feet at Hunstanton to 30 feet at Speeton. He considered that the Carstone does not represent the Tealby series of Lincolnshire, and that it is probably Aptian or Upper Neocomian, but containing in its lowest part fossils derived from the disintegration of Lower Necomian beds, in the same manner as the deposits of phosphatic nodules at Potton and Upware.

Mr. Whitaker objected to the use of chemical characters in the identification of beds, and thought that the presence of the same fossils did not necessarily prove the identity of the Red Chalk and the Gault.

Mr. Wiltshire, in reply, maintained the sufficiency of the Palæontological evidence, that furnished by the species of *Ammonites* being especially remarkable.

February 24, 1869.

Henry Cook, Esq., M.D., H.M. Bombay Medical Service; Lieut. William Innes, R.E.; H. R. Moiser, Esq., Heworth Grange, York; R. Hill Tiddeman, Esq., B.A., Oriel College, Oxford, and Samuel Allport, Esq., Snow Hill, Birmingham, were elected Fellows.

The following communication was read:—

On the Distribution *of the* British Postglacial Mammals.
By W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.

§ 1. *Introduction.*—The materials on which this essay is founded are the result of ten years' work on the Pleistocene Mammalia of Great Britain, during which every public Museum and private collection of note in the United Kingdom has been examined, either by myself or by some one on whose judgment I could depend. To undertake to chronicle all the Pleistocene Mammals that have been found in Britain is a task that cannot be undertaken with any degree of satisfaction, because the new discoveries that are daily being made render its perfect completion impossible; but, nevertheless, I prefer to bring before the Society the results at which I have arrived at the present time, rather than to await the higher knowledge that possibly might have been acquired during the vicissitudes of another decade. In the only English text-book on the Fossil Mammals*, the Preglacial Fauna is confused with the Postglacial, and that again with the Prehistoric. There is not even a complete list in print of the species that compose any one of these three great groups of Mammals. The numerous undescribed species in Preglacial collections from the forest-bed of Norfolk and Suffolk render it impossible to give a complete list of the Mammalia of that formation, or to trace the precise relation that they bear to those of the Pliocenes of the south of France and Lombardy. The British Prehistoric Mammals have already been defined in the essay that is now being printed by the International Congress of Prehistoric Archæology†. My present object is to define, as sharply as possible, the Postglacial Mammals from those of the preceding and succeeding epochs, to show their distribution in Britain, to prove the identity of the Cave-fauna with that of the Postglacial River-beds, and, lastly, to examine the evidence as to the climate of the epoch.

The term Postglacial is used as the exact equivalent of the Quaternary of Mr. Prestwich and the French *savants*, and the Post-pliocene of Sir Charles Lyell, and is applied to that group of animals which have been proved, by the labours of Dr. Falconer, M. Lartet‡, and others to have inhabited France, Germany, and Britain after the Glacial period, and which most probably invaded the portions of the Preglacial continent that were not submerged while the great boulder-drift was falling from the melting icebergs that floated over the depressed area in northern Europe.

§ 2. *Distribution of Postglacial Mammals throughout England and Wales.*—All the cases that I have been able to collect of the occurrence of fossil mammals in the more ancient caves and in the high- and low-level gravels of England and Wales, are arranged in the following table in natural, and their localities in alphabetical, order. All doubtful species have been omitted. For the determination of the animals from the caves of Wales I am indebted in part to Mr. W. A. Sanford, F.G.S., and the late Dr. Falconer, F.R.S. §; for that of the Mammals of Brixham, to Prof. Busk, F.R.S., and for those of Salisbury to Dr. Blackmore, F.G.S.

* British Fossil Mammals, 8vo. 1846. † Norwich Meeting, 1868.

‡ Falconer, Palæont. Mem. 1868. Lartet, Comptes Rendus, t. xlvi.

§ *Op. cit.* vol. ii.

Table of Distribution of British Postglacial

List of Species. Caves.	Bacon's Hole, Gower.	Banwell.	Bench Cave, Brixham.	Berry Head, Torbay.	Bleadon.	Bosco's Hole, Gower.	Boughton Cave, Maidstone.	Box Hill, Bath.	Brixham.	Burrington, Somerset.	Caswell Bay, Gower.	Cefn.	Coygau Cave, Caermarthen.	Crawley Rock, Gower.	Crow Hole, Gower.	Deborah Den, Gower.	Durdham Down.	Hutton, Somerset.	Kent's Hole.	Kirby Moorside.	Kirkdale.	Llandebie, Llandeilo.	Long Hole, Gower.
Homo, *L.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*	...	...	...	*
Rhinolophus ferrum-equinum, *Leach*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Vespertilio noctula, *Schreb.*	...	?	...	...	...	...	...	...	...	?	...	...	...	...	...	...	...	?	...	...	...	...	...
Sorex vulgaris, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Ursus arctos, *L.*	...	...	...	...	*	...	...	...	*	...	...	...	...	...	...	?	*	...	*	...	*	*	...
U. spelæus, *Gold.*	*	*	...	...	*	*	...	...	*	*	...	*	...	...	*	?	...	*	*	*	*	...	*
U. ferox, *L.*	...	...	...	...	...	...	...	...	*	...	...	*	...	...	...	?	...	...	*	...	*	...	...
Gulo luscus, *Lab.*	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Meles taxus, *L.*	*	...	*	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	*
Mustela erminea, *L.*	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	...
M. putorius, *L.*	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
M. martes, *L.*	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Lutra vulgaris, *Erxl.*	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	...	...	*
Canis vulpes, *L.*	*	...	*	...	*	*	...	...	*	...	*	...	...	...	*	...	...	*	*	...	*	...	*
C. lupus, *L.*	*	...	*	...	*	*	...	...	*	...	...	*	...	...	*	*	...	*	*	...	*	...	*
Hyæna spelæa, *Gold.*	*	...	*	...	*	...	*	...	*	*	*	*	*	...	...	...	*	*	*	...	*	...	*
Felis catus, *L.*	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
F. (antiqua) pardus, *L.*	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...
F. leo (var. spelæa, *Gold.*)	...	...	...	...	*	...	...	...	*	...	*	*	...	...	...	...	*	*	*	*	*	...	*
F. lynx, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Machairodus latidens, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Cervus megaceros, *Hart*	...	...	...	...	*	...	...	...	*	...	...	*	...	...	...	...	...	*	*	...	*	...	*
Alces malchis, *Gray*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...
Cervus Browni, *Dawkins*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. tarandus, *L.*	*	*	*	*	*	*	*	...	*	...	*	*	*	...	...	...	...	*	*	...	*	...	*
C. capreolus, *L.*	*	...	...	...	*	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. elaphus, *L.*	*	...	...	...	*	...	*	...	*	...	*	*	...	...	...	...	...	...	*	...	*	...	*
Ovibos moschatus, *Desm.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bos primigenius, *Boj.*	...	...	*	...	*	...	*	...	*	...	*	...	...	...	...	...	...	...	*	...	...	...	...
Bison priscus, *Ow.*	*	*	*	...	*	*	...	*	...	...	?	...	*	...	*	...	...	*	?	...	*	...	*
Hippopotamus major, *Desm.*	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	*	...	?	...	*	...	...
Sus scrofa, *L.*	*	...	...	...	*	*	...	...	...	...	...	...	...	...	*	...	...	...	*	...	...	...	*
Equus caballus, *L.*	...	...	...	...	*	...	*	...	*	...	*	*	*	...	...	...	*	*	*	...	*	...	*
Rhinoceros megarhinus, *Christ.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
R. leptorhinus, *Ow.*	*	...	...	...	...	...	...	...	*	...	...	*	*	*	*	...	*	...	...	...	*	...	*
R. tichorhinus, *Cuv.*	...	...	...	*	...	...	*	...	...	...	*	*	...	...	...	...	...	...	*	...	...	...	*
Elephas antiquus, *Falc.*	*	...	...	...	*	...	...	...	...	...	...	*	...	...	*	...	*	...	...	...	*	...	*
E. primigenius, *Blum.*	...	...	*	...	*	...	*	*	*	...	...	...	*	...	...	...	*	*	*	...	...	...	*
Lemmus, sp.	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lepus cuniculus, *Pall.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*	...	*	...	*
L. timidus, *Erxl.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*	...	*	...	*
Lagomys spelæus, *Ow.*	...	...	...	...	*	...	...	...	*	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Spermophilus erythrogenoides, *Falc.*	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
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Arvicola pratensis, *Bell*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
A. agrestis, *Flem.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	...
A. amphibius, *Desm.*	*	...	...	...	...	*	...	...	...	...	...	...	...	...	*	...	...	...	*	...	*	...	*
Castor fiber, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Mus musculus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...

Mammalia—England and Wales.

Minchin Hole, Gower.	North Hill Tor, Gower.	Oreston, Devon.	Paviland, Gower.	Pleasley Vale, Derbyshire.	Portland Fissure.	Ravenscliff, Gower.	Sandford Hill.	Spritsail Tor, Gower.	Uphill, Somerset.	Wirksworth, Derbyshire.	Wookey Hole.	Yew-tree Cave, Pleasley.	River-deposits.	Abbots Langley, Herts.	Abingdon, Berks.	Alconbury, Huntingdon.	Aylesford, Kent.	Aymestry, Hereford.	Ballingdon, Essex.	Barnston, Notts.	Barnwell, Cambridge.	Barnwood, Glo'ster.	Beckford, Glo'ster.	Bedford.	Bemerton, Salisbury.	Bielbecks, Yorkshire.	Bonchurch, I. of Wight.	Bracklesham, Sussex.	Brandsburton, York.	Brentford.	Bricklehampton and Cropthorn.	Bridport, Dorset.
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Table of Distribution of British Postglacial

List of Species.	River-deposits.																							
	Brighton.	Bromwich Hill, Warwick.	Burfield, Worcester.	Cambridge.	Camps Hill, Hertford.	Canterbury.	Chatham.	Chedzoy, Somerset.	Clapton.	Cold Higham, Northampton.	Copen Hall, Cheshire.	Copford, Essex.	Culham, Oxfordshire.	Defford, Worcester.	Dorking.	Droitwich.	Dunkirk, off.	Eckington on Avon.	Fawler, Oxford.	Fisherton, Salisbury.	Fladbury, Worcester.	Fleets Bank, Worcester.	Folkestone.	Freshford, Bath.
Homo, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Rhinolophus ferrum-equinum, *Leach*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Vespertilio noctula, *Schr.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sorex vulgaris, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ursus arctos, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U. spelæus, *Gold.*	...	...	...	...	...	...	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...
U. ferox, *L.*	...	...	...	...	...	...	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...
Gulo luscus, *Lab.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Meles taxus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mustela erminea, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
M. putorius, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
M. martes, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lutra vulgaris, *Erxl.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Canis vulpes, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
C. lupus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hyæna spelæa, *Gold.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Felis catus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
F. (antiqua) pardus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
F. leo (var. spelæa, *Gold.*)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
F. lynx, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Machairodus latidens, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cervus megaceros, *Hart.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...
Alces malchis, *Gray*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cervus Browni, *Dawkins*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. tarandus, *L.*	...	...	...	...	*	...	...	...	...	...	...	...	*	...	...	...	...	*	...	*	*	...	...	*
C. capreolus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
C. elaphus, *L.*	*	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	*	*	...	...	...	*	...
Ovibos moschatus, *Desm.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Bos primigenius, *Boj.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Bison priscus, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	*	...	*	*	...	*	*
Hippopotamus major, *Desm.*	*	...	...	*	...	...	...	*	...	*	...	...	...	...	...	...	...	*	...	...	...	...	*	...
Sus scrofa, *L.*	*	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	*	...	...	...	...
Equus caballus, *L.*	*	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	*
Rhinoceros megarhinus, *Christ.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
R. leptorhinus, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
R. tichorhinus, *Cuv.*	*	*	*	...	*	*	*	...	...	*	...	...	*	...	...	...	...	*	...	*	*	*	*	...
Elephas antiquus, *Falc.*	...	...	...	*	...	*	...	...	...	...	*	...	*	...	...	...	...	...	...	...	...	...	...	...
E. primigenius, *Blum.*	*	*	...	...	*	...	...	*	*	...	...	...	*	...	*	*	*	*	...	*	*	...	...	*
Lemmus, sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Lepus cuniculus, *Pall.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
L. timidus, *Erxl.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
Lagomys spelæus, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Spermophilus erythrogenoides, *Falc.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...
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Arvicola pratensis, *Bell*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
A. agrestis, *Flem.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
A. amphibius, *Desm.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Castor Fiber, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mus musculus, *L.*	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...

Mammalia—England and Wales (*continued*).

German Ocean.	Gloucester.	Green Street Green, Bromley, Kent.	Halston, Stratford-on-Avon.	Hanborough, Oxford.	Harrowdean, Welling-boro', Northampton.	Harswell, Yorkshire.	Hartlip, Bath.	Harwich.	Hedingham, Essex.	Herne Bay.	High Lugwardine, Hereford.	Hill-Head, Titchfield.	Hinton, Somerset.	Holyhead Harbour.	Hoxne, Suffolk.
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Huntingdonshire, G. N. R.	Hurley Bottom, Berks.	Icklingham, Suffolk.	Iffley, Oxford.	Ilminster, Somerset.	Ipswich.	Isle of Wight.	Kew.	Lark Hall, Bath.	Lawford, Rugby.	Leeds.	Lexden, Colchester.	Little Comberton, Worcester.	London.
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Table of Distribution of British Postglacial

List of Species.	River-deposits.																							
	Loxbrook, Bath.	Maidenhead, Berks.	Malvern.	Milford Hill, Salisbury.	Moulsham, Chelmsford.	Murston, Sittingbourne.	Newington, Kent.	No man's Shoal, Isle of Wight.	Otterham, Kent.	Oundle, Northampton.	Overton, York.	Oxford.	Peasmarsh, Guildford.	Peckham, Surrey.	Peterborough.	Pettridge Common, Surrey.	Plymouth raised beach.	Reculvers, Kent.	Rugby.	St. Audries, Somerset.	Sittingbourne, Kent.	Stour Valley, Worcester.	Stroud, Glo'ster.	Thame, Oxford.
Homo, *L.*	...	...	...	*	...	...	...	...	...	...	...	...	*	...	...	...	...	*	...	...	...	...	...	...
Rhinolophus ferrum-equinum, *Leach*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Vespertilio noctula, *Schr.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sorex vulgaris, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ursus arctos, *L.*	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U. spelæus, *Gold.*	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
U. ferox, *L.*	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gulo luscus, *Lab.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Meles taxus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mustela erminea, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...
M. putorius, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
M. martes, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lutra vulgaris, *Erxl.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Canis vulpes, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. lupus, *L.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Hyæna spelæa, *Gold.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Felis catus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
F. (antiqua) pardus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
F. leo (var. spelæa, *Gold.*)	*	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	*	...	...	...
F. lynx, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Machairodus latidens, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cervus megaceros, *Hart.*	*	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...
Alces malchis, *Gray*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cervus Browni, *Dawkins*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. tarandus, *L.*	*	...	...	...	...	*	...	...	*	...	...	*	...	...	...	...	...	...	...	...	*	...	*	...
C. capreolus, *L.*	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...
C. elaphus, *L.*	...	...	...	...	...	...	...	*	...	*	...	*	...	...	...	...	...	...	*	...	...	...	...	*
Ovibos moschatus, *Desm.*	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bos primigenius, *Boj.*	*	...	...	...	*	...	...	...	...	*	...	?	...	*	...	...	...	...	...	...	...	...	*	*
Bison priscus, *Ow.*	*	...	...	...	?	*	...	...	...	...	...	*	...	*	*	...	...	...	...	...	*	...	...	*
Hippopotamus major, *Desm.*	...	...	...	...	*	...	...	...	...	...	*	*	...	*	...	...	...	...	...	...	...	...	...	*
Sus scrofa, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Equus caballus, *L.*	*	...	...	...	...	*	...	...	*	*	...	*	...	...	...	...	...	...	...	...	*	...	...	...
Rhinoceros megarhinus, *Christ.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
R. leptorhinus, *Ow.*	...	*	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*
R. tichorhinus, *Cuv.*	*	...	...	...	...	*	*	...	...	...	...	*	...	*	...	*	...	...	...	...	*	...	*	*
Elephas antiquus, *Falc.*	...	...	...	...	...	...	...	...	...	*	...	*	...	*	...	...	...	...	...	...	...	...	...	...
E. primigenius, *Blum.*	*	*	*	*	...	*	*	...	*	*	...	*	*	*	...	...	...	...	*	*	*	*	*	*
Lemmus, sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lepus cuniculus, *Pall.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
L. timidus, *Erxl.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lagomys spelæus, *Ow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Spermophilus erythrogenoides, *Falc.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
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Arvicola pratensis, *Bell*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
A. agrestis, *Flem.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
A. amphibius, *Desm.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Castor fiber, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mus musculus, *L.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Mammalia—England and Wales (*continued*).

Thames, Lower.	Thetford, Norfolk.	Tisbury, Wilts.	Tooting, Surrey.	Tewkesbury.	Walton, Essex.	Wealden area.	Weston-super-Mare.	Whitstable, Kent.	Wilton Jail, Taunton.	Windsor.	Woodstock Road Station.	Worcester.	Wyre, near Pershore.	Yarmouth, dredged at.	Caves, Summary.	River-deposits, Summary.	Total of Occurrences.	Scotland.	Ireland.	Preglacial Forest-bed.	Clacton.	Lower Brickearths.	Prehistoric Deposits.
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§ 3. *Authorities.*—The various Museums in which the species mentioned in the foregoing table are preserved, together with the authorities on which some of the determinations were made, are arranged in the following order:—

Authorities for Cave Mammalia.

Bacon's Hole.—Swansea Mus., on Dr. Falconer's authority. Palæont. Mem. vol. ii. pp. 183, 325, 340, 349, 501.

Banwell.—Beard Collection, Taunton Museum. The remains ascribed to this locality in Oxford and London were obtained from some of the Mendip caves.

Bench Cave.—On the authority of Mr. W. A. Sanford.

Berry Head (Ashhole Cavern).—Brit. Museum. Owen, Brit. Foss. Mammals.

Bleadon.—Mus. Taunton.

Bosco's Hole.—Swansea Mus., on Dr. Falconer's authority, Palæont. Mem. vol. ii. pp. 510, 589.

Boughton Cave.—Brit. Mus.; Mus. Oxford; Geol. Soc.; Chichester; Sir Ph. Egerton; Lord Enniskillen.

Box Hill.—The remains were exhibited at a meeting of the British Association at Bath.

Brixham.—Sir Ph. Egerton; Brit. Mus. I have to thank Mr. George Busk, F.R.S., for a perfect list of species from this cave.

Burrington.—Beard Coll., Mus. Taunton.

Caswell Bay.—Mus. Swansea; Oxford.

Cefn.—Mus. Sir Philip Egerton; Dr. Falconer, Palæont. Mem. vol. ii. pp. 210, 541.

Coygau Cave.—Coll. Mr. Hicks (St. Davids); Mr. Allen, Regent's Park.

Crawley Rock.—Mus. Oxford.

Crow Hole.—Swansea Mus., on Dr. Falconer's authority, Palæont. Mem. vol. ii. p. 519.

Deborah Den.—Swansea Mus., on Dr. Falconer's authority, Palæont. Mem. vol. ii. p. 467.

Durdham Down.—Mus. Bristol; Lord Enniskillen.

Hutton.—Mus. Taunton.

Kent's Hole.—Geol. Soc. Mus.; Collection of Sir Ph. Egerton; Mus. of Coll. Surg., of Geol. Survey, of Oxford, of Lord Enniskillen.

Kirby Moorside.—Mus. Coll. Surg.

Kirkdale.—Brit. Mus.; Mus. Coll. Surg.; Geol. Soc.; Oxford; Sir Ph. Egerton; Lord Enniskillen.

Llandebie.—Oxford Mus.

Long Hole.—On Dr. Falconer's authority, Palæont. Mem. vol. ii. pp. 400, 525, 538.

Minchin Hole.—Brit. Mus.; Swansea Mus., on the authority of Dr. Falconer and Mr. W. A. Sanford, Palæont. Mem. vol. ii. pp. 181, 184, 325, 340, 352, 507, 589.

North Hill Tor.—Falconer's Memoirs, vol. ii. p. 457.

Oreston.—Brit. Mus.; Mus. of Leeds, Jermyn Street, and Geol. Society.

Paviland.—Mus. Oxford; Swansea. I am indebted to Dr. Falconer and Mr. W. A. Sanford for part of these determinations.

Pleasley Vale.—Mus. Geological Survey.

Portland Fissure.—Mus. Oxford; Geological Society.

Ravenscliff.—On the authority of Dr. Falconer, Palæont. Mem. vol. ii. p. 519.

Sandford Hill.—Mus. Taunton.
Spritsail Tor.—On the authority of Dr. Falconer, Palæont. Mem. vol. ii. pp. 179, 462, 477, 522.
Uphill.—Mus. Bath; Taunton; Sir Philip Egerton.
Wirksworth.—Mus. Oxford; Dr. Buckland, Reliquiæ Diluvianæ.
Wookey Hole.—Museums of Brighton, Bristol, Oxford, Taunton, Leeds, Lord Enniskillen, Mr. W. A. Sanford, and Mr. James Parker.
Yew-tree Cave.—Coll. Dr. Ransom, Nottingham.

Authorities for River-bed Mammalia.

Abbots Langley.—Coll. John Evans, F.R.S.
Abingdon.—Mus. Oxford.
Alconbury.—On Prof. Owen's authority, Brit. Foss. Mamm.
Aylesford.—Mus. Chichester; Geological Survey.
Aymestry.—On Prof. Owen's authority, Brit. Foss. Mamm.
Ballingdon.—Brit. Mus.
Barnston.—Mus. York.
Barnwell.—Brit. Mus.; Mus. Cambridge, Quart. Journ. Geol. Soc. vol. xxii. p. 470.
Barnwood.—Mus. Gloucester.
Beckford.—Coll. in Hereford.
Bedford.—Coll. Mr. Wyatt, Quart. Journ. Geol. Soc. vol. xx. p. 184.
Bemerton.—Quart. Journ. Geol. Soc. vol. xx. p. 190.
Bielbecks.—Mus. York, Philosoph. Mag. vol. vi. p. 225.
Bonchurch.—Mus. Coll. Surg.
Bracklesham.—Mus. Chichester; Brit. Mus.
Brandsburton.—Mus. York.
Brentford.—Brit. Mus.; Mus. Coll. Surg.; Mr. T. Layton (Kew Bridge); Geological Soc. See Philosoph. Trans. 1833.
Bricklehampton and Cropthorne.—Mus. Coll. Surg.; Geological Soc. (Strickland's Mem. p. 96); Apperley Court.
Bridport.—Mus. Coll. Surg.
Brighton.—Brit. Mus.; Mus. Geological Survey; Brighton.
Bromwich Hill.—Mus. Worcester.
Cambridge.—Mus. Cambridge; Coll. Surg.; Quart. Journ. Geol. Soc. vol. xxii. p. 470.
Camps Hill.—Mus. Geological Survey; Quart. Journ. Geol. Soc. vol. xxiv. p. 283.
Canterbury.—Brit. Mus.; Coll. Mr. Deane (Canterbury). The remains from Chartham are included under this head.
Chatham.—Mus. Geol. Soc.
Chedzoy.—Coll. Mr. W. A. Sanford.
Clapton.—Brit. Mus.
Cold Higham.—Brit. Mus.
Copen Hall.—Mus. Sir P. Egerton.
Copford.—Coll. Mr. John Brown, of Stanway; Brit. Mus.
Culham.—Coll. Mr. James Parker.
Defford.—Strickland Coll., Apperley Court.
Dorking.—Mus. Geological Survey.
Droitwich.—Mus. Worcester.
Dunkirk, off.—Coll. Dr. Bree (Colchester).
Eckington-on-Avon.—Strickland Coll., Apperley Court; Mus. Worcester.
Fawler.—Coll. Mr. James Parker (Oxford).
Fisherton.—Quart. Journ. Geol. Soc. vol. xxi. p. 252; and rity of Mr. W. A. Sanford.

FLADBURY.—Mus. Worcester.
FLEETS BANK.—Mus. Worcester.
FOLKESTONE.—Mus. Geol. Soc.
FRESHFORD.—Mus. Bath; Rev. H. H. Winwood.
GERMAN OCEAN.—Coll. Mr. C. B. Rose, and Mr. Owles (Yarmouth).
GLOUCESTER.—Mus. Gloucester.
GREEN-STREET GREEN.—Brit. Mus.; Mus. Geol. Survey; Sir John Lubbock, 'Prehistoric Times,' p. 271.
HALSTON.—Mus. Coll. Surg.
HANBOROUGH.—Coll. James Parker.
HARROWDEAN.—Brit. Mus.
HARSWELL.—Mus. York.
HARTLIP.—Mus. Maidstone; Geological Survey.
HARWICH.—Brit. Mus.; Mus. Colchester; Dr. Bree (Colchester).
HEDINGHAM.—Brit. Mus.
HERNE BAY.—Brit. Mus.
HIGH LUGWARDINE.—Coll. Rev. W. Symonds (Pendock).
HILL-HEAD.—Quart. Journ. Geol. Soc. vol. xx. p. 189.
HINTON.—Mus. Coll. Surg.
HOLYHEAD HARBOUR.—Brit. Mus.
HOXNE.—Mus. Soc. Antiquaries; Oxford; Brit. Mus.
HUNTINGDONSHIRE, G. N. R.—Mus. Geological Survey.
HURLEY BOTTOM.—Mus. Oxford; Mem. of Geol. Survey, vii. p. 81.
ICKLINGHAM.—Quart. Journ. Geol. Soc. vol. xxiii. p. 45.
IFLEY.—Mus. Coll. Surg.
ILMINSTER.—Mus. Bath.
IPSWICH.—Brit. Mus.; Mr. R. Fitch (Norwich).
ISLE OF WIGHT.—Mus. Geological Survey.
KEW.—Coll. Mr. T. Layton (Kew Bridge).
LARK HALL.—Mus. Bath; Rev. H. H. Winwood.
LAWFORD.—Mus. Oxford; Sir P. Egerton.
LEEDS.—Mus. Leeds.
LEXDEN.—Mus. Cambridge; Geological Survey; Rev. O. Fisher; Brit. Mus.
LITTLE COMBERTON.—Mus. Worcester.
LONDON.—Under this head are included Deptford, Gray's-inn-Lane, Camden Town, Chelsea, and other suburbs. Mus. Coll. Surg., of Mr. J. Wetherell, Geological Survey, and British Mus.
LOXBROOK.—Coll. Rev. H. H. Winwood.
MAIDENHEAD.—Brit. Mus.; Quart. Journ. Geol. Soc. xii. p. 124.
MALVERN.—Mus. Geological Survey.
MILFORD HILL.—Quart. Journ. Geol. Soc. xxi. p. 250.
MOULSHAM.—Brit. Mus.; Mus, Geological Survey.
MURSTON.—Mus. Geological Survey.
NEWINGTON.—Mus. Geological Survey.
NO MAN'S SHOAL.—Brit. Mus.
OTTERHAM.—Mus. Geol. Survey.
OUNDLE.—Brit. Mus.
OVERTON.—Mus. York.
OXFORD.—Oxford Mus. Some of these remains were dredged out of the Cherwell.
PEASMARSH.—Prestwich, Quart. Journ. Geol. Soc. Aug. 1861.
PECKHAM.—Brit. Mus.
PETTRIDGE COMMON.—Mus. Geol. Survey.
PLYMOUTH RAISED BEACH.—Mus. Coll. Surg.
RECULVERS.—Quart. Journ. Geol. Soc. xxiii. p. 50.
RUGBY.—Brit. Mus.; Mus. Cambridge.

SAINT AUDRIES.—Mus. Taunton; Sir Alexander Hood.
SITTINGBOURNE.—Mus. Geol. Survey; Dr. Grayling.
STOUR VALLEY.—Brit. Mus.
STROUD.—Coll. Mr. Lucy (Gloucester).
TEWKESBURY.—On the authority of Prof. Owen (Brit. Foss. Mamm.).
THAME.—Coll. Mr. T. Coddrington; Quart. Journ. Geol. Soc. xx. p. 374.
THAMES, LOWER.—Brit. Mus.; Mus. Coll. Surg.
THETFORD.—Quart. Journ. Geol. Soc. xxiii. p. 45.
TISBURY.—Brit. Mus. Mus. Geological Survey.
TOOTING.—Mus. Geological Survey.
WALTON.—Brit. Mus.; Mus. Cambridge, Colchester, Geological Survey, Oxford, Geological Soc., and Dr. Bree.
WEALDEN AREA.—Mus. Folkestone.
WESTON-SUPER-MARE.—Geological Mag. vol. iii. p. 115.
WHITSTABLE.—Brit. Mus.
WILTON JAIL.—Mus. Taunton.
WINDSOR.—Mus. Geological Survey; Captain Luard, R.E.
WOODSTOCK ROAD STATION.—Coll. Mr. James Parker.
WORCESTER MUSEUM.—Worcester.
WYRE.—Strickland Coll., Apperley Court.
YARMOUTH.—Brit. Mus.; Mr. Nash (Yarmouth).

§ 4. *Notes on the Species.*—Order Carnivora, family Ursidæ, species *Ursus ferox*. The existence of the Grizzly Bear in Europe was proved by Prof. Busk in 1867*, as well as its probable identity with *U. priscus* of Dr. Schmerling. It is probably also identical with the *Ursus Leiodensis* of the latter author, and with the *U. Bourguignati* from the Maritime Alps, described by M. Lartet in the Annales des Sciences Naturelles†.

Order Carnivora, family Mustelidæ, species *Gulo luscus*. The Wolverine, or Glutton, the great pest of the fur-hunters of Siberia and North America, has been determined as a British fossil by Mr. W. A. Sanford. Two of the characteristic canines of that animal have been found in the Mendip caves, in Banwell and Bleadon, and are preserved in the Taunton museum.

Order Carnivora, family Felidæ, species *Felis pardus*. The existence of the Panther in Britain was proved in 1865, by a canine from Banwell Cave, in the collection of the Earl of Enniskillen, and by two canines, a molar, femur, ulna, and two metatarsals from the Bleadon Cave ‡. It is most probably identical with the *F. antiqua* of Cuvier, from the osseous breccia of Cette §.

Order Carnivora, family Felidæ, species *Felis leo*, var. *spelæa*. The specific identity of *Felis spelæa* with the living *F. leo* of Africa and Asia has been proved in the monograph on the animal published by the Palæontographical Society ||.

Order Carnivora, family Felidæ, species *Felis lynx*. We are indebted to Dr. Ransom for the discovery of a lower jaw and skull

* Quart. Journ. Geol. Soc. vol. xxiii. p. 342.
† 5e Série, tome viii. p. 157, pl. ix.
‡ See Cat. Taunton Mus. Nos. 616–623.
§ This was also the opinion of the late Dr. Falconer, expressed verbally to me.
|| British Pleistocene Mammalia, Parts I., II., III.

of an animal hitherto unknown in Britain, in a fissure that penetrates the Permian limestone of Pleasley Vale, termed the Yew-tree Cave. They were associated with the remains of wolf, fox, roedeer, and other animals. "No confident opinion, founded on the position of the bones on the floor of the cave, could be formed as to their relative ages, as the dribbling of water through the loose stones of the floor carries away and displaces the mud and objects imbedded in it"*. The geological age, therefore, of the remains in the cave cannot be determined with absolute certainty. So far as the internal evidence goes, they may be of Prehistoric or even of Historic date, with as great probability as Postglacial; but, nevertheless, there are two circumstances which render the latter hypothesis the most tenable. The Tichorhine Rhinoceros, Mammoth, and Bison have been found in a cave in the neighbourhood; and therefore Postglacial mammals occupied that district. In the second place, the carnivore in question must have crossed over into Derbyshire while Britain formed part of the mainland of Europe, or, in other words, during the Postglacial epoch; for it is impossible to suppose that it could have invaded our island from France or Germany during Prehistoric times, and that it should have been brought over by the care of man is most unlikely. I have therefore felt justified in considering it a member of the Postglacial Fauna, although direct evidence is wanting. It is undistinguishable from the Lynx inhabiting Norway at the present day.

Order Carnivora, genus *Machairodus*, species *Machairodus latidens*, Owen. The fact that, out of all the numerous localities in which the remains of fossil mammals have been found in Britain, Kent's Hole Cavern alone should have furnished traces of this most formidable Pliocene carnivore, inclined the late Dr. Falconer to doubt its having been found in that cavern†. The canines on which the species is founded are four in number, and are preserved in the British Museum, and in those of Oxford, the College of Surgeons, and the Geological Society. Their mineral condition and the colour of the adherent matrix are identical with those of the Kent's-Hole fossils; and the manuscripts of their discoverer, the Rev. J. MacEnery, published in 1859‡, prove, beyond all doubt, that the Cultridens (=Machairodus) was found in the cave along with "Elephants, Elks, Horses, Hyæna, and myriads of Rodentia." The teeth in question also can be satisfactorily traced from the MacEnery collection to the museums in which they are preserved: those in the British and Oxford Museums were purchased and presented by Dr. Lovell Phillips; that in the Museum of the College of Surgeons was presented by Lord Enniskillen, for whom, most probably, it was purchased by Dr. Battersby; while that in the Museum of the Geological Society was presented by Mrs. Cazalet, along with other remains from the cave. The incisor figured by Prof. Owen in the

* British Association Report, Nottingham, 1866, paper read before Section C.

† Palæontological Memoirs, vol. ii. p. 549.

‡ Cavern Researches, by the late Rev. J. MacEnery, F.G.S.; edited by E. Vivian, Esq. 8vo, pp. 32, 33.

'British Fossil Mammals,' fig. 70, and reproduced by M. Gervais as a British specimen, cannot now be traced, and therefore cannot be admitted in evidence of the existence of *Machairodus* in Britain. Dr. Falconer inclines to the belief that the *Machairodus latidens* was specifically identical with the *M. cultridens* of the Val d'Arno; but since the remains are so very fragmentary, and since they are indisputably broader in proportion to their length than the Italian specimens, it is safer to preserve Prof. Owen's name in the English nomenclature.

Order Ruminantia, family Cervidæ, species *Cervus megaceros*, Hart. There seems to be no reason for exchanging the name *Cervus megaceros*, proposed by Dr. Hart * in 1830, for that of *Megaceros hibernicus*, proposed by Professor Owen in 1843, since no difference of even subgeneric value has been adduced to separate it from the great genus *Cervus* †. It is identical with the *Cervus giganteus* of M. Gervais, and the *C. euryceros* of Dr. Falconer.

Order Ruminantia, family Cervidæ, species *Cervus tarandus*. *Cervus tarandus*, L., includes *Cervus priscus*, Cuv., *C. guettardi*, Cuv., and *C. Bucklandi*, Owen ‡, which have been proved, by the large series of antlers from Gower § and the Mendip caves, to be merely varietal forms assumed by the antlers of one and the same species.

Order Ruminantia, family Cervidæ, species *Cervus elaphus*. The fragment of Cervine antler from Kent's Hole, on which Prof. Owen founds his species *Strongyloceros spelæus* ||, cannot be differentiated, save by its slightly larger size, from the corresponding portion of the antler of the Red Deer. It forms one extreme of a series passing from the largest fossil to the smallest living antler, and therefore cannot be said to indicate a new Cervine species. The right lower ramus, figured (fig. 195) as Cervine, and ascribed to *Strongyloceros spelæus* ?, is proved, by the large development of the accessory column in the true molars 1 and 2, to belong not to a Cervine but to a Bovine species. In the absence, therefore, of evidence to the contrary, *Strongyloceros spelæus* is included under *Cervus elaphus*, L.

Order Ruminantia, family Ovidæ, species *Ovibos moschatus*. The Musk-Sheep, more commonly called, from its size, the Musk-Ox, has been proved by M. Lartet ¶, De Blainville **, and myself †† to have nothing in common with the ox or buffalo tribe, save its large size. The name, therefore, *Ovibos moschatus*, proposed by De Blainville in 1816, and indorsed by the high authority of Sir John Richardson ‡‡, must be accepted instead of the name *Bubalus moschatus* pro-

* A Description of the Skeleton of the Fossil Deer of Ireland. 8vo. 1830.

† Owen, Report of British Association, 1843, p. 237; Brit. Foss. Mammals, p. 445.

‡ Cuvier, Oss. Foss. tome iv. pl. vi. figs. 14–17, pl. vii. fig. 11. Owen, Brit. Foss. Mammals, p. 485, fig. 200.

§ Falconer, Palæontological Memoirs, vol. ii. p. 525.

|| Brit. Foss. Mammals, p. 469, fig. 193.

¶ Comptes Rendus, tome lviii. p. 26.

** Bull. Soc. Philom. 1816, p. 81.

†† Essay on *Ovibos moschatus*, in the possession of the Royal Society.

‡‡ Zool. H.M.S. 'Herald,' 1852.

posed by Prof. Owen in 1856 *, under the mistaken idea that the skull found at Maidenhead belonged to the same genus as that of the Cape Buffalo. There is nothing in common between the skulls of the two animals except the superficial resemblance of the downward direction of the horncores †.

Order Perissodactyla, genus *Rhinoceros*, species *Rhinoceros leptorhinus*, Owen. This term is used as the exact equivalent of the *R. hemitœchus* of Dr. Falconer, and of the *R. Merckii* of M. Lartet. If the validity of the species *R. leptorhinus* of Cuvier be proved by subsequent investigation, *R. leptorhinus* of Owen must be exchanged for *R. hemitœchus* of Falconer, and Cuvier's species must be taken to represent *R. megarhinus* of Christol.

Order Proboscidea, genus *Elephas*, species *Elephas antiquus*, Falc. This species includes also the *Elephas priscus* that was proposed by Dr. Falconer, and afterwards withdrawn.

With the exception of the above species, there are none deserving of any especial note among the Postglacial Mammals, there being no clash of opinion among scientific men as to their nomenclature or affinities.

Three animals have been purposely omitted from the list of Postglacial species:—the Fallow deer (*Cervus dama*), which is doubtfully inserted by Prof. Owen, but which really cannot boast an antiquity in this country higher than that of the Roman occupation; the small Short-horn (*Bos longifrons*), which did not make its appearance in Europe until the characteristic Postglacial mammals had passed away; and the *Capra hircus*, which was brought to this country probably by the hand of man during the Prehistoric epoch.

The Squirrel and the smaller rodents wild in Britain probably crossed over to this country during the Postglacial epoch, although the former, from its arboreal habits, and the majority of the latter, from their small size, have not been found in any deposit of that age. It would have been impossible for them to have invaded Britain after its insulation from the mainland of Europe.

§ 5. *Identity of the Mammalia of the Caves with those of the River-beds.*—We have now to discuss the inferences which necessarily flow from the foregoing data. And first as regards the relation of the fossil mammals of the caves to those of the river-deposits. Dr. Falconer, in his memorable essay on the Caves of Gower‡, established the fact that all the caves in Britain with which he was acquainted belong to one and the same Postglacial geological epoch. A glance at the table of distribution shows, not only the truth of this conclusion, but further, that the entire group of cave-mammals is identical with that of the river-deposits. Out of a sum total of 47 mammals found in both, *Rhinoceros megarhinus* and *Cervus Browni* being excepted, there are but 15 cave-mammals that have not been found in the latter, namely, two species of Bat, the Glutton, Badger, Ermine, Stoat, Otter, Panther, Lynx, *Machairodus*, Elk, *Spermo-*

* Quart. Journ. Geol. Soc. vol. xii. p. 124.

† On this point the Osteological Catalogue of the Oxford Museum, No. 552, gives ample details.

‡ *Op. cit.* vol. ii.

philus erythrogenoides, *Arvicola pratensis*, *A. agrestis*, and *A. amphibius*. None of these are of any special value in classification except the *Machairodus*, to the discussion of which animal we shall return. On the other hand, out of 31 mammals found in the river-deposits there is only one, the Musk-Sheep, which has not been found in the caves. There can, therefore, be no doubt that the deposits in the caverns are palæontologically synchronous with those in the river-beds.

§ 6. *Predominant Animals.*—Fossil remains indicate the comparative numbers of the animals to which they belonged, only when their destructibility and size are taken into consideration. Thus the stone-like molars of the Mammoth would survive the destruction of all traces of the bones of the smaller animals, and remain in many instances as the sole evidence that Postglacial mammals ever dwelt in the area where they were found. The carnivores also must necessarily be fewer in number than their prey, the herbivora; and therefore their remains must also be more rare. Moreover the ruminants that shed their antlers annually cannot be compared with those of their order with persistent horns, because out of equal numbers of each the former will leave far more abundant traces. Keeping these facts in mind, it is not at all remarkable that the Mammoth should be more abundantly found in England than any other mammal; but when it is compared with *Elephas antiquus* it will be seen that their relative numbers stand in the proportion of 82 to 30 *. Had all the cases of the isolated occurrence of the former animal been noted, the numerical difference would have been far greater. The tichorhine Rhinoceros stands in relation to the leptorhine in the proportion of 54 to 18; the Reindeer to the Red-deer and Roedeer as 44 to 30 and 8. The numerical proportion of the Bison to the Urus was as 49 to 27; that of the *Hyæna spelæa* to the Cave Lion as 29 to 28; that of the Wolf to the Fox as 27 to 22. The few traces of the Musk-Sheep show that it was a stranger, and very rare in Britain, as compared with Bisons and Uri.

The comparatively few traces of man that have been found, when the indestructibility of his implements of stone and chert is taken into consideration, prove that he was not only few in numbers, but also that for a very long period he did not use flint implements in Britain †.

§ 7. *Postglacial Mammals of Scotland and Ireland.*—The number of the localities in England and Wales that have furnished Postglacial mammals is at the least 148. We will proceed now to the examination of those found in Scotland. The earliest recorded discovery is that made in 1817, of the Mammoth in the parish of

* The 36 caves added to 112 river-deposits furnish the common denominator, 148, to these numbers.

† I am indebted to Mr. John Evans, F.R.S., for the following additional localities that have furnished palæolithic implements—Bournemouth, Fordingbridge, Isle of Wight, Swalecliff, Canterbury, Highbury, King's Lynn, Bury St. Edmunds, Brandon, Shrub Hill; and to Mr. Whitaker, F.G.S., for the following—Horton Kirby, in the valley of the Darent, Luton, Shefford, Valley of Medway south of Rochester (Kent).

Kilmaurs in Ayrshire *, in a deposit of sand and clay, which has been proved by Mr. Bryce to underlie the till. Antlers of Reindeer have also been obtained from the same stratum, and are now deposited in the Hunterian Museum, Glasgow. The remarkable fact that these two animals were derived from beds underneath the till does not imply that Scotland has been submerged since they lived in that country; for it is very probable, as Mr. Geikie † has shown, that the till in some places is the result of the melting of land-ice, and not of icebergs floating on the sea. The second instance on record is that of the Mammoth from the Union Canal, between Edinburgh and Falkirk ‡. A tusk was found at Clifton Hall in the stiff boulder-clay, 15 or 20 feet from the surface, in such preservation that it was sold to an ivory-turner for £2. Before it was rescued by Sir Gibson Maitland it had been sawn asunder for the manufacture of chessmen. The third locality is that of Chapel Hall §, near Airdrie, in Dumbartonshire, where a bone of the Mammoth was obtained from a deposit underlying the till, at a height of 350 feet above the sea. Mr. Geikie assigns the Reindeer-antler found in a cutting of the Forth and Clyde Junction Railway, in the parish of Kilmarnock ||, to the period of the till. It was obtained from a bed of blue clay, at a height of about 100 feet above the sea. Mr. James Geikie has also described the occurrence of a skull of Urus in a lacustrine deposit intercalated in the boulder-drift at Croftshead, Renfrewshire ¶.

With the exception of these five cases, I know of no evidence that Postglacial mammals ever existed in Scotland. The remains of other animals, such as Urus, Reddeer, and the like, have been obtained from marl-beds underlying the peat or from alluvia, which are Prehistoric and not Postglacial.

In Ireland ** there are two localities only that have furnished remains of indisputably Postglacial age. Four teeth of the Mammoth were found, in digging the foundations of a house, at Maghery, near Belturbet, in Cavan. In the south, a cave near Dungarvan has furnished the remains of *Ursus* (*U. spelæus*? *U. arctos*?), Mammoth, and Reindeer. A tusk of *Hippopotamus*, which I have been unable to trace, is also quoted, by Mr. Scott, from the boulder-clay of Carrickfergus; but the account of its discovery is not circumstantial.

Thus there is evidence that, for some reason or other, the Postglacial mammals, so abundant in England, were extremely rare both in Scotland and Ireland.

§ 8. *Cause of unequal distribution.*—What adequate cause, then, can be assigned for the unequal distribution of the mammals in the

* Mem. Wern. Soc. vol. iv. p. 64.

† Trans. Geol. Soc. Glasgow, vol. i. part ii. p. 70; Quart. Journ. Geol. Soc. vol. xxi. p. 213.

‡ Mem. Wern. Soc. vol. iv. p. 58.

§ Proc. Geol. Soc. vol. iii. p. 415. See Bryce, Geol. Arran, p. 9.

|| Edin. New Phil. Journ. N.S. vol. vi. p. 105; Trans. Geol. Soc. Glasgow, vol. i. part ii. p. 71.

¶ Geological Magazine, vol. v. pp. 393, 486, 535.

** Journ. Geol. Soc. Dublin, Feb. 10th, 1864, vol. x. p. 103.

superficial deposits of Great Britain and Ireland? The fact that they are not altogether absent from Scotland and Ireland would imply that those two countries were not insulated from the mainland of Europe during the whole of the Postglacial epoch. And yet there must have been some barrier to prevent their immigration. It is undoubtedly true that since Scotland was submerged to a depth of 2000 feet (deeper than any other part of Britain has yet been proved to have been submerged), the Scotch lowlands would emerge from the waves of the glacial sea long after middle and south Britain had been occupied by the Postglacial mammals, if the rate of elevation were equal over the whole British area; their remains, therefore, might be expected to be more rarely met with in Scotland than in England. Sir Charles Lyell* accounts in this manner for the rarity of Postglacial mammals in Ireland. But while this may be one of the causes, it seems to be only secondary and subordinate to another which as yet has not been explained. A map on which I have laid down the distribution of the Postglacial mammals in the United Kingdom (and which any one can construct for himself by using the Table of distribution) shows large areas in which I have no evidence that Postglacial Mammalia have as yet been discovered. A line drawn from St. David's Head due east as far as Hereford, and thence passing northwards through Shrewsbury, and sweeping round in a westerly direction through St. Asaph as far as Holyhead, circumscribes with the sea-board a region which is singularly devoid of Postglacial mammals, but which has been proved by Professor Ramsay to be full of traces of terrestrial glacial action. Again, a line drawn from the mouth of the Ribble to that of the Tees is the southern boundary of the barren area of Cumberland, Westmoreland, North Lancashire and Northumberland, in which Mr. Hull has met with unequivocal traces of the former existence of glaciers†. In Scotland and Ireland the proofs of long-continued subaerial glaciation are most ample and abundant‡.

These areas therefore agree, not only in the rarity or absence of the fossil mammals, but also in presenting traces of the action of land-ice. If the two phenomena be coupled together we have in my opinion a *vera causa*. If we suppose that the ice-sheet, the work of which looks so fresh and recent in these areas, was in existence while the Postglacial mammals were dwelling in Britain, their scarcity or absence must of necessity follow. In Scotland, the fact that in two cases the Mammoth has been found underneath, and in one case in the midst of the till, implies that in that country glacial phenomena were going on while Postglacial mammals were living in the neighbourhood. Both Mr. A. Geikie and Sir Charles Lyell agree in the belief that the glaciers had not forsaken the Scotch highlands in the days when man dwelt on the banks of the Somme and in the valley of the Thames. On the whole, therefore, it may be assumed, with a very high degree of probability, that the higher grounds of North Wales and of the barren areas in England and

* Antiquity of Man.

† Edinburgh New Phil. Journ. 1860.

‡ Geikie, Trans. Geol. Soc. Glasgow, vol. i. pl. 2.

Ireland were covered with an ice-mantle *at the same time* that the Mammoth, Reindeer, and other Postglacial animals were living in the lower and less inclement districts. The evidence of distribution is most important in carrying out this correlation.

§ 9. *Relation of Postglacial to Preglacial Mammals.*—We have now to discuss the relation of the Postglacial mammals to those that inhabited the counties of Norfolk and Suffolk, and roamed over the ancient plain which extended from the Wash to the mouth of the Rhine in Preglacial times. First of all we must define what the Preglacial mammals are. The following very incomplete list is the result of the examination of all the remains from the Forest-bed in the King, Gunn, Gurney, and Layton collections, and in the Museums of London, Oxford, Cambridge, and Norwich, as well as those in private hands in Cromer and Yarmouth.

List of Preglacial Mammals.

Ursus Arvernensis.	Bos primigenius.
U. spelæus (? Etruscus).	Hippopotamus major.
Sorex.	Equus fossilis.
Mygale moschata.	Rhinoceros megarhinus.
Talpa Europæa.	R. Etruscus.
Cervus megaceros ?	Elephas antiquus.
C. capreolus.	E. meridionalis.
C. elaphus.	Arvicola amphibia.
C. Sedgwickii.	Castor fiber.
C. Ardeus.	Trogontherium Cuvieri.

Besides these, there are many specific forms which cannot be determined until they have been carefully compared with those of the Pliocenes of the South of France and Lombardy. To this list Dr. Falconer would add the Mammoth; but a careful investigation into the evidence which was supposed to establish its Preglacial age has convinced me that the inference is faulty. The specimens reputed to come from the forest-bed are, in every case, mere waifs and strays thrown up by the sea between high- and low-water mark, or very possibly derived from the gravels and sands above the boulder-clay. The remains dredged up from the bed of the sea, in the collection of Mr. Owles, establish the fact that a Postglacial deposit containing Reindeer, Tichorhine Rhinoceros, and Mammoth exists off Yarmouth, which very probably was the source whence some of the drifted remains were ultimately derived.

Out of these nineteen animals that inhabited Britain before the deposit of the boulder-clay, all but seven survived the great Glacial change, and formed an integral portion of the Postglacial fauna. The seven exceptions consist of *Ursus Arvernensis, Rhinoceros Etruscus, Elephas meridionalis, Cervus ardeus, Cervus Sedgwickii, Trogontherium*, and *Mygale moschata*, the latter of which still flourishes on the banks of the Don and Volga. To these the Pliocene species *Rhinoceros megarhinus* might have been added, had it not occurred in the Lower brickearths of the Thames Valley. The eleven or twelve survivors bind together indissolubly the Pre- and Postglacial groups, and forbid the idea of the existence of any gap or lacuna which would warrant the classification of the one as Tertiary and the other as Quaternary.

All the Preglacial animals now alive are to be found in temperate regions; and there is every reason to believe that the extinct species also rejoiced in a temperate or moderately warm climate.

We have now the materials for the definition of the Postglacial mammals. The Preglacial *Ursus spelæus?*, *Sorex*, *Talpa Europæa*, *Cervus megaceros?*, *C. capreolus*, *C. elaphus*, *Bos primigenius*, *Hippopotamus major*, *Equus fossilis*, *Elephas antiquus* and *Castor fiber* held their own ground against the invaders from other geographical provinces. The Leptorhine Rhinoceros of Owen, although absent from the forest-bed, is found abundantly in the Pliocenes in the north of Italy. All that can be said about the Cats, the Brown and Grizzly Bears, the Badger, Ermine, Stoat, Otter, Wolf and Fox, Bison, Wild Boar, Hare, Rabbit, *Arvicola agrestis*, *A. pratensis*, and the common Mouse, is that none of them have yet been found in the Forest-bed. The remaining group of Postglacial mammals, consisting of the Glutton, the Reindeer, Elk, Musk-sheep, two kinds of pouched Marmots, the Cave-pika, the Lemming, and the two extinct species *Rhinoceros tichorhinus* and *Elephas primigenius*, appear in strong contrast to the other animals. They probably migrated, as M. Lartet has suggested, from their ancient home in Siberia; and their advent in Britain defines the Postglacial from the Preglacial fauna. The presence of Palæolithic Man, the Cave-lion, and Cave-hyæna may also be considered characteristic.

§ 10. *Relation of Postglacial to Prehistoric Mammals.*—The Sheep, Goat, *Bos longifrons*, and Dog make their appearance for the first time in the Prehistoric epoch in alluvia and bone-caves, sometimes with and sometimes without the traces of Man. All four are found round the Pfahlbauten of the Stone age in Switzerland*; and there is no evidence against the supposition that they may have been introduced by the hand of man into Central and Western Europe. The whole group of Postglacial Pachydermata, as well as the Cave-lion, Cave-hyæna, and Cave-bear, the Lynx, *Machairodus*, and all the northern Mammalia, with the exception of the Elk and Reindeer, had vanished away at the close of the Postglacial epoch. The Bison, moreover, was no longer found in our island. The rest of the Postglacial mammals, comprising, for the most part, the smaller species, lived on, such as the Brown Bear, Irish Elk, and the others that are given in the Table of distribution.

§ 11. *Characteristic Postglacial Mammals.*—The following may be regarded as the fossil mammals that characterize British Postglacial deposits from those that went before and followed after:—

Palæolithic Man.	The Musk-sheep.
The Glutton.	The tichorhine Rhinoceros.
The Cave-bear?	The Mammoth.
The Grizzly Bear?	The Lemming.
The Cave-lion.	The Cave-pika.
The Cave-hyæna.	The Pouched Marmot.
The Panther?	Spermophilus erythrogenoides.

* Rütimeyer, Fauna der Pfahlbauten.

§ 12. *The Age of the Lower Brick-earths of the Thames Valley, and of the deposit at Clacton.*—In the foregoing Table of distribution of British Postglacial Mammals I have not classified the river-deposits of Clacton, Grays, Ilford, and Crayford with those undoubtedly Postglacial, because of the conflicting evidence of their faunas as to their true place in the geological scale. The list of Mammalia found in them is inserted in the Table of distribution immediately after those from the forest-bed. We will proceed to sum up the whole of the palæontological evidence which they offer.

The occurrence at Clacton * of the *Rhinoceros leptorhinus* of Owen, of *Elephas antiquus, Hippopotamus major,* Irish Elk, Horse, and Urus may be accounted for equally well by the assumption of its Pre- or Postglacial age; for these animals dwelt in Europe both before and after the Glacial epoch. A new species of Deer, *Cervus Browni,* is closely allied to the Fallow Deer that ranges in a wild state only over the warm districts around the Mediterranean. The Bison points in the Postglacial direction; but it will most probably be proved by future investigations on the Continent to have lived in Europe during the Preglacial period. At least the number of Preglacial localities that have been examined is not sufficiently large to give value to the induction that, because it has not been noted, therefore it did not exist. For the most part it has been confounded by naturalists with the Urus and *Bos longifrons.* The Cave-lion, on the other hand, has been so well determined that the balance of evidence is in favour of its Postglacial age. With its exception, then, there is nothing that forbids the supposition of the Preglacial age of the deposit; but nevertheless, since the characteristic mammals of the Forest-bed are absent, it would be hazardous to ascribe it to that age. And in the same way, since the Reindeer, Mammoth, Tichorhine Rhinoceros, and other equally common and characteristic Postglacial mammals are also absent, it cannot be said to belong to the class of deposits that contain their remains. We are therefore justified in assuming that it represents in point of geological time an epoch during which some of the more hardy Preglacial and Pliocene species lived under a temperature too severe for the more delicate of their congeners, and not cold enough for the invasion of the Reindeer and the allied Arctic forms.

The Lower Brickearths of the Thames Valley at Ilford, Grays Thurrock, and Crayford contain the remains of *Rhinoceros megarhinus,* which has not yet been yielded, in France, Germany, or Italy, by any strata of later age than the Pliocene, and are therefore brought into more intimate relation with that epoch than any other of the deposits undoubtedly Postglacial. But nevertheless the evidence afforded by the Mammoth, Tichorhine Rhinoceros, Cave-lion and Cave-hyæna is in favour of their Postglacial date. And this inference is strongly corroborated by my discovery of a skull of a Musk-sheep at Crayford since the essay on the Lower Brickearths was written †. How, then, can we reconcile the clash of evidence?

* Geol. Magazine, vol. v. p. 213.

† Quart. Journ. Geol. Soc. May 1867, p. 91.

Could the Megarhine or Southern species of Rhinoceros have dwelt under the same climate as the Musk-sheep? I think this altogether impossible. Had the constitution of the former animal been sufficiently elastic, it would have held its own ground against the invading animals from the north and east after the manner of its fellow the *R. leptorhinus* of the French and Italian Pliocenes. There is, however, one view that has the merit of explaining the difficulty, and which therefore is probably true. During the depression of North Germany and the greater portion of Britain, those parts of the Preglacial continent now represented by France and the south of England were not submerged; for in that case they would present some traces of the deposit of icebergs, which were so numerous in the North Sea of the period. It is hardly within reason to suppose that all proof of submergence beneath the Glacial sea could have been removed by subaerial denudation from so large an area, while to the north of the Thames, and in North Germany, it is so abundant and so ample. It is therefore probable that the valley of the Lower Thames roughly marks the position of the ancient Glacial coast-line in Britain, and that to the south the relics of the Preglacial continent extended without a break through France into Italy; while to the north the look-out was over a dreary expanse of sea burdened with icebergs, like that off the coast of Newfoundland.

The temperate or moderately warm climate that prevailed over the British portion of the Preglacial continent before the depression took place, must have been lowered by the presence of so much melting ice as is implied by the presence of the Boulder-clay, and especially in the neighbourhood of the coast-line, independently of any great change flowing from some other unknown and cosmical cause. This climatal change must have banished to a certain extent the Preglacial mammals from the area over which it was felt; but nevertheless it is highly consistent with what we know of the migration of Herbivores to suppose that now and then some of them, such as *R. megarhinus*, may have ventured northwards as far as the valley of the Thames.

Again, M. Lartet has shown, in his memorable essay on the migration of mammals, that the Arctic division of the Postglacial or Quaternary mammalia (the Mammoth and Tichorhine Rhinoceros and the rest) invaded Europe from their ancient home in the north of Asia (where they probably dwelt during the Pliocene epoch, Tertiary, in Western and Central Europe) at the commencement of the European Quaternary or Postglacial period, the change in the Pliocene temperature, coupled very possibly with the depression of land in North Siberia, causing the animals inhabiting that area to advance westwards and southwards and to occupy the feeding-grounds till then belonging to the Pliocene fauna. This immigration very probably began while Northern Europe was *being depressed* beneath the waves in the Boulder-clay epoch. If this be admitted, there is nothing improbable in the hypothesis that the North Asiatic immigrants would gradually creep round the shores of the Glacial sea, and here and there occupy in the winter the pastures that afforded food to Preglacial or Pliocene mammals in the summer. And in this way the remains of animals indisputably Preglacial or Pliocene may be mingled with those indisputably Postglacial or Quaternary in the deposits of the same stream. Thus the presence of the *R. megarhinus* and of the hardier members of the Preglacial fauna, the Red Deer, Horse, Urus, and possibly *C. megaceros*, in association with the Mammoth, Tichorhine Rhinoceros, and Musk-sheep may be accounted for. On these grounds the deposits in question have been separated from the ordinary Postglacial series. They probably form the first terms of the Postglacial series, and point back to a time when the Postglacial invaders had not taken full possession of the district. And inasmuch as no North-Asiatic mammal has yet been found at Clacton, while several have been found in the Lower Brickearths, the former is considered of higher antiquity than the latter. They bridge over that vast interval between the Preglacial or Pliocene and the Postglacial or Quaternary epochs that is sharply marked in Britain north of the Thames by the deposit of the Boulder-clay, but which in the south of England and in France and Italy is not clearly defined. On this hypothesis the passage from the Pliocene to the Postglacial series would be as follows:—1, Pliocene of France and Italy; 2, Preglacial (? Pliocene) of Forest-bed; 3, Passage-bed of Clacton; 4, Postglacial Passage-beds of the Thames valley; 5, Postglacial series. I am unable to offer any opinion about the identity of the Forest-bed fauna with that of the foreign Pliocenes.

There is also another point bearing on the question of the relation of the Pliocene to the Postglacial fauna that I have referred to this place, the occurrence of the Pliocene *Machairodus* in the midst of the remains of Reindeer, Cave-hyæna, Mammoth, Tichorhine Rhinoceros, and other characteristic Postglacial mammals. Its presence can only be accounted for on the supposition that it strayed northwards from its southern habitat, very much after the fashion of its living congener the Tiger of Northern Asia. There is nothing more improbable in the idea that a small body of southern carnivores should have preyed upon the Reindeer in the neighbourhood of Kent's Hole than that a Tiger specifically identical with that of India should at the present day find convenient food among the herbivores of Siberia. It indicates, however, one important fact, that while the Postglacial mammals were in full occupation of Britain, the Pliocene fauna to which belongs *Machairodus* occupied a zoological province further to the south.

13. *Postglacial Climate.*—We have now, in conclusion, to consider what was the nature of the climate under which the Postglacial mammals lived. Sir Charles Lyell and the authors of the 'British Pleistocene Mammalia' agree in the belief that it was continental in character, while Britain formed a part of the Postglacial continent, or, in other words, that the extreme cold of winter and the extreme summer-heat were more intense than in the present condition of things. The evidence of the contorted gravels, and the traces of terrestrial glacial

action, show that the winter at least was such as may now be felt in the woodland region of northern Siberia. The presence of the arctic group of mammals, the Reindeer, Musk-sheep, and the like, implies that the climate under which they lived was severe. But, on the other hand, the presence of the *Hippopotamus major* in 29 localities, an animal that, so far as we can judge by the habits of the living species, could not have endured the low temperature now necessary for the wellbeing of the Musk-sheep or Reindeer, involves the necessity of supposing the climate to have been temperate or comparatively warm. M. Lartet, in his last Essay on the "Carnassiers et Rhinocères fossiles du Midi de la France" *, explains the difficulty in the following way:—First of all, he assumes that the arctic herbivores dwelt in France *throughout the year* side by side with the Hippopotamus; and then he infers that the Postglacial climate was more equable and insular than that of France at the present day. But it is established beyond all cavil that during the time the Postglacial fauna occupied Britain our island formed an integral portion of the continent of Europe—a fact that would at once demolish the idea of the existence of an insular climate during that epoch. The Hippopotamus most probably was, as Sir Charles Lyell suggests, a summer visitant only, and retired southwards in the winter to a more genial clime. I know of no other hypothesis that satisfies all the conditions of the problem.

From that time down to the present day the climate has gradually been modified. As Britain became insular the climate grew more equable, until in the Prehistoric epoch the sole survivors of the northern invaders were the Elk and Reindeer †, the latter of which grew more and more scarce until at last it became extinct in the mountains of Caithness towards the end of the twelfth century.

Discussion.

The President suggested that a fourth period might be added to the three adopted by the author, viz. the Glacial period, during which it would appear from the paper that some, if not all, of the "postglacial" animals may have lived in Britain.

Mr. Busk remarked that some of the genera referred to both the Postglacial and Preglacial periods (such, for instance, as the Hyæna, Lion, and Hippopotamus) were of southern, and not, like many of the others, of northern and eastern origin. The Lynx also might not improbably be of African descent. It was abundant in the bone-breccia of Gibraltar, as was also the *Cervus elaphus* and *C. dama*. *Elephas antiquus* and *Rhinoceros* might also be regarded as southern forms; and it was worth consideration whether these portions of the fauna might not be connected with the time when Southern Europe was joined on to Northern Africa.

Mr. Tate stated that at Carrickfergus there was a forest-bed underlying glacial drift, from which possibly the elephant-remains found there had been derived.

* Ann. des. Sc. Nat. tome viii. p. 157 *et seq.*

† "On the Range of the Reindeer," Pop. Science Review, 1867.

Mr. J. W. Flower objected to all the fossils attributed to the Postglacial period being regarded as synchronous, and to the cave- and river-deposits being classed together.

Mr. Evans hoped that at some time a chronological arrangement of British caves might be proposed. He mentioned the discovery of a palæolithic flint implement in a brickfield at Highbury, and argued against the lower-level deposits of the Thames valley being regarded as more ancient than the higher.

Mr. Topley called attention to the absence of river-gravels and caves in the Silurian region of Wales and of the North, which was owing mainly to the absence of limestone adapted for the formation of caves and of material for gravels.

Prof. Ramsay argued that caves such as those in which mammalian remains occur must have existed in preglacial time, and therefore that it would be strange if none of those explored contained preglacial remains. He was not satisfied as to the cause of the Thames forming a line of demarcation marking the absence of Glacial deposits. It could only be accounted for in his mind by the valley of the Thames having been entirely excavated since the Glacial period, though he acknowledged this was a bold speculation. He had always regarded the Thames-valley deposits as postglacial.

Mr. Whitaker thought that the brick-earth of the lower part of the Thames valley was one of the later deposits in that valley, and therefore Postglacial. Beneath the *Corbicula*-bed of Crayford there were shells of some of the common living species of the neighbourhood. He saw no such extreme difficulty in the excavation of the Thames valley since the deposition of the Boulder-clay.

Mr. Gwyn Jeffreys mentioned the *Helix ruderata* and *H. fruticum* as being instances of shells of northern character occurring in the Thames valley at Ilford. No shells of an arctic or boreal character occurred in the South of England; so that it would appear that it had not been submerged during the Glacial period.

Mr. Prestwich was glad to find that the opinion of the Thames-valley deposits being Postglacial was gaining ground. He called attention to the existence in France of river-gravels belonging to an earlier period, such as that near Chartres; so that such might exist elsewhere. He could not reconcile the occurrence of *Hippopotamus* so far north as Leeds with its annual migration, as had been suggested.

Mr. Godwin-Austen agreed with the view of the author of the 'Reliquiæ Diluvianæ,' that the animals whose remains occur in caves lived prior to the submergence which filled the caves, or, in other words, to the Glacial period. He thought that it was impossible for all the animals whose remains occurred in the River-gravels to have occupied the land surface at the same time. He considered that English geologists were too prone to argue from phenomena confined to this country. A long island must have existed where now is the South of England at the Glacial period; but he thought that at that time all animal life must have ceased there. If so, our divisions of time could not apply to the Continent, where no such extreme changes in conditions took place.

Mr. W. Boyd Dawkins, in reply, admitted that possibly some animals classed as Postglacial belonged also to the Glacial period; but for convenience' sake he had adopted the three divisions in the paper. He saw no necessity for any of the animals being of purely southern origin. He did not identify the Lower Brick-earth of the Thames valley with the other river-deposits, though, from the presence of the Musk-sheep, he was inclined to place them later than at one time he did. The only reason he could give for the absence of Preglacial caves both in England and on the Continent was, that the rocks containing them may have been removed by denudation.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On DAKOSAURUS *from the* KIMMERIDGE CLAY *of* SHOTOVER HILL.

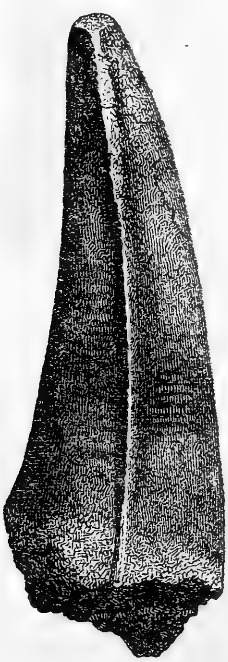
By J. WOOD MASON, Esq., F.G.S.

(Read Nov. 25, 1868*.)

EARLY in the spring of 1866 I obtained from the Kimmeridge Clay of Shotover-hill, near Oxford, four entire teeth and one portion of a tooth of *Dakosaurus*, which is now for the first time described and figured as a British genus.

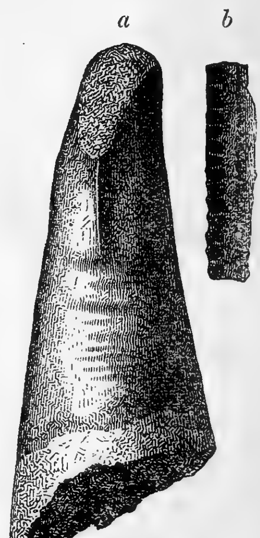
The only description of this reptile with which I am acquainted is to be found in Quenstedt's 'Der Jura†.' This author, after mentioning the circumstance of his having described it in a former work under the name of *Megalosaurus*, states that the only part of the skeleton known is a portion of a lower jaw containing six teeth, which are implanted in distinct sockets (*Alveolen*): a detached tooth, figured in the work referred to, well expresses the general characters given below, even to the crenulation of the trenchant margins.

Fig. 1.



Posterior view of largest tooth of *Dakosaurus*.

Fig. 2.



a. Anterior view of tooth of *Dakosaurus*.
b. Portion of ridge of same, highly magnified to show crenulation.

* For the discussion on this paper see p. 16 of the present volume.
† P. 785, Atlas, tab. 97. fig. 11.

It is noticed by Prof. Owen*, who rightly includes it among his "amphicœlian" Crocodilia.

Teeth of *Dakosaurus* are said to occur, associated with remains of *Pliosaurus, Gyrodus, Sphærodus gigas,* &c., in the Potton Sands described by Mr. Seeley; these are its companions, both in the Upper White Jura of Schnaitheim and in the Kimmeridge Clay of England. Mr. Walker† also mentions it as occurring in beds probably of the same age at Upware, in the Fens of Cambridge, and in similar company.

I have examined, through the kindness of Mr. W. Davies, a suite of the Potton fossils at the British Museum; but it would be almost impossible, owing to the worn condition of these fossils, which have evidently been derived from older rocks, to determine with any degree of certainty its presence among them.

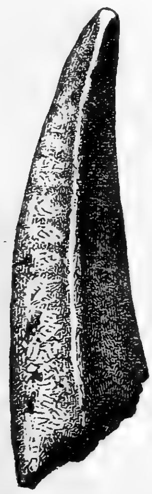
The British Museum contains numerous specimens of *Dakosaurus* from the German locality, as well as a single tooth from the Kimmeridge Clay of Boulogne and one from that of Ely, near Cambridge. A comparison of these with the teeth from Oxford fails to discover differences of specific value; I therefore propose to retain M. Quenstedt's name of *maximus* for the latter.

Fig, 3.

a *b*

a. External view of tooth of *Dakosaurus*, the ridges forming the contour lines.
b. The same tooth, showing the pulp-cavity.

Fig. 4.



Side view of an anterior tooth of *Dakosaurus*.

This genus is characterized by large, conical, incurved and slightly recurved teeth, the smooth and polished enamelled crowns of which are traversed by two sharp, prominent, minutely crenulated longitudinal ridges, one forming the posterior, the other the anterior margin of the tooth; these ridges are situated "midway between the convex and concave curvatures of the tooth," which is compressed at the apex so as to give in transverse section a slightly oval figure pointed before and behind; but this character dies away towards the base, where the crown becomes cylindrical and ceases to be interrupted by the ridges; one of these, the anterior, is lost sooner than the other, which is continued a short distance into the cement-

* Palæontology, 2nd edit. p. 300.

† Geol. Mag. vol. iv. p. 309.

covered base; this base is widely excavated by a conical pulp-cavity, which ends rather suddenly. The outer surfaces of the teeth are flatter than the inner ones, which are almost semicircular; this is strongly marked in the case of fig. 3, in which the backward curve completely overbalances the incurvation.

It is evident that figs. 1 and 2 could only have belonged either to the right side of the lower or to the left side of the upper jaw, and that fig. 3 occupied a position either on the left side of the lower or the right side of the upper jaw among the posterior teeth, which probably, as in *Pliosaurus*, were both smaller and more recurved. Fig. 4, a more compressed form, is perfectly symmetrical and must be allowed to have had a place among the most anterior teeth, if one be guided by the fact that these, in existing Crocodiles (*e.g.* in *C. biporcatus*), gradually become symmetrical as they approach the middle line. To the fragmentary tooth, reduced perhaps to its present condition in the animal's mouth, may be assigned the same sides of the jaw as fig. 3.

Scattered over the four entire teeth are several faint constrictions or annular depressions, very similar to the effect produced upon the finger by a tightly fitting ring (fig. 2).

The enamel is very thin, and shows under a lens of moderate power inconspicuous longitudinal wrinkles.

The greatest length of the largest tooth (fig. 1) is 2 inches 8 lines; its transverse diameter at the base=11 lines; its antero-posterior diameter, also at the base, =1 inch 1 line.

Similar measurements, taken about $\frac{3}{4}$ in. from the apex of the same specimen, give 6 and 9 lines respectively.

Teeth similar in their essential characters to those described and figured above, and differing from them only in such trifling matters as the presence of enamel ridges and constrictions below the crown, are to be seen in the anterior region of the mouth in all recent (true) Crocodiles and Alligators; but in these the posterior teeth, both in the upper and lower jaw, differ enormously from the anterior ones—a fact of considerable importance, and one that may well serve as a caution to the palæontologist who is disposed to found a genus or species upon characters furnished by a single tooth.

To conclude, the crenulation of the trenchant ridges is by no means peculiar to the teeth under consideration, but is observable, to a greater or less extent in those of all Crocodilian reptiles * that I have ever examined, from the remotest known ancestor to the living representatives of the order—in a word, from the Triassic *Belodon* † (an indubitable crocodilian) to *Crocodilus bombifrons*, which, with its congener *C. biporcatus* and the Gavial, preserves its destructive existence in the waters of the Ganges.

* Unworn teeth of the Crocodilian genera *Jacare*, *Mecistops*, and *Rhynchosuchus* have not yet fallen under my notice, but I have succeeded in tracing crenulation plainly in teeth of *Steneosaurus*, and more faintly in those of *Teleosaurus* and the Gangetic Gavial.

† It is only right to state that I was led to examine the remains of this reptile contained in the British Museum, as well as Von Meyer's figures ("Muschelkalksaurier," tab. 20. fig. 6, Palæontographica, Band. x. Taf. 38–40 &c.) by Prof. Huxley's statement of its Crocodilian affinities.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY.

From October 1st to December 31st, 1868.

I. TRANSACTIONS AND JOURNALS.

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American Journal of Science and Art. Second Series. Vol. xlvi. Nos. 137 & 138. September and November 1868.

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American Naturalist. Vol. ii. Nos. 8–10. October to December 1868.

J. Wyman.—Freshwater Shell-heaps of the St. John's River, East Florida, 393, 449 (1 plate).
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W. T. Brigham.—Earthquakes, 539.

Anthropological Review, and Journal of the Anthropological Society of London. Nos. 22 & 23. July and October 1868.

Athenæum Journal. Nos. 2136–2148.

H. C. Sorby.—Chalk, 432.
G. C. Wallich.—Chalk, 464, 532.
T. H. Huxley.—Chalk, 497.
C. Beke.—Gold-fields of Eastern Africa, 604, 644.
Solfatara, 606.
Vesuvius, 718.

Berlin. Monatsbericht der königl.-preussischen Akademie der Wissenschaften zu Berlin. July and August 1868.

E. Reusch.—Körnerprobe am zweiachsigen Glimmer, 428.

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W. T. Brigham.—Notes on the Volcanic Phenomena of the Hawaiian Islands, with a description of modern Eruptions, 341 (4 plates).

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H. Mann.—Crater of Haleakala (Hawaiian Islands), 112.
S. H. Scudder.—Fossil Insects from the Colorado, 117.
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S. H. Scudder.—Fossil Insects from the Coal-measures, 401.

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W. T. Blanford.—Geology of Abyssinia, 169.

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T. Sterry Hunt.—The Object and Method of Mineralogy, 238.

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C. M. Warren and H. F. Storer.—Examination of Naphtha obtained from a Rangoon Petroleum, 288.

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Geinitz.—Die fossilen Fischschuppen aus dem Plänerkalke in Strehlen, 31 (4 plates).

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

March 10, 1869.

Thomas Bloxam, Esq., F.C.S., Lecturer on Chemistry and Natural Philosophy in Cheltenham College, and Joseph John Murphy, Esq., of Old Forge, Dunmurry, co. Antrim, were elected Fellows of the Society.

The following communications were read:—

1. *On the* Origin *of the* Northampton Sand. By John W. Judd, Esq., F.G.S., of the Geological Survey of England.

[This paper has been withdrawn by permission of the Council.]

2. *On the* Occurrence *of* Remains *of* Eurypterus *and* Pterygotus *in the* Upper Silurian Rocks *in* Herefordshire. By the Rev. P. B. Brodie, M.A., F.G.S.

During a recent visit to Herefordshire I was fortunate enough to discover a great number and variety of Crustacean remains belonging mostly to *Eurypterus* and *Pterygotus*, the former predominating, some portions of which may perhaps differ from any yet figured and described—though my friend Mr. Woodward, to whom I have sent them for examination, is inclined to think that there are no new species among them. Their abundance and excellent state of preservation makes the discovery of interest, because I believe none have yet been found anywhere in Palæozoic rocks in England so perfect or well preserved. The remains consist for the most part of considerable portions of the body (the largest measuring a little more than 1 inch in breadth near the middle of the body, and $2\frac{1}{4}$ inches in length without the head or tail, which are wanting) with attached body-rings and other appendages but having neither head nor tail, single body-rings of large size, detached heads, thoracic segments, tails of *Eurypterus megalops*, swimming-feet, claws, &c. Many might have been obtained entire, if the thin stratum in which they occur could have been worked; but from its position it was impossible to procure anything but detached fragments (though every piece of shale was crowded with them), so that the Crustacea were invariably broken, and I fractured many entire specimens in consequence. They are of a uniform brown colour, while those from Lesmahago, in Scotland, are always black, and are of the identical colour of the altered Silurian formation in which they are imbedded. There are but few places in the Silurian area of Woolhope where the so-called passage-beds, or the intermediate strata between them and the Old Red Sandstone are exposed; but some parts of this series may be seen in an old quarry at Purton, near Stoke Edith. At one end of the quarry there is a fine-grained, moderately hard, yellow sandstone, which may represent the Downton Sandstone; but although the position of the Old Red Sandstone can easily be detected by the colour of the soil in the lower ground between that spot and the railway-station, and towards Hagley Dome, neither the exact thickness, nor the character of the intervening bands can be accurately determined. A mason informed me that this yellow sandstone was an excellent building-stone, and of considerable thickness; if this represents the true Downton Sandstone, then the rich crustacean-bed may belong to the bone-bed series, as the upper Ludlow shales underlie it; for, supposing the overlying sandstone to be the "Downton rock," it would determine the true position of the crustacean zone. This sandstone is immediately underlain by a coarse sandy bed full of remains of plants, including seed-vessels of Lycopodiaceæ, and fragments of *Eurypterus* and *Pterygotus*. This is succeeded, in descending order, by a thin stratum of sandstone, below which is the thin band of pale green, micaceous, sandy marl, only a few inches thick, so rich in Crustacea, which is again underlain by another thin layer of sandstone, below the whole of which the Upper Ludlow formation, with the usual fossils, appears rising at a considerable angle; and the entire section indicates considerable disturbance. A few small well-preserved seed-vessels, univalves, and *Beyrichiæ*, and a small coral, are associated with the *Eurypterus* in the stratum referred to. At Ludlow the section, when exposed, showed:—1, the Old Red Sandstone; and, 2, passage-beds, with *Cephalaspis*, *Pterygotus*, and *Eurypterus*. At Ludford-lane adjacent, the following lower beds are seen:—

1. Downton Sandstone.
2. Shale containing *Platyschisma helicites* &c.
3. Bone-bed, about 2 inches
4. Stratum with fragments of *Pterygotus* &c.
5. Upper Ludlow.

No. 4 in this section appears to correspond most nearly with the

Eurypterus-zone at Stoke Edith. At Ledbury, according to Mr. Lightbody, there is a thickness of 300 feet between the Downton Sandstone and the passage-beds. At Stoke I could find no trace of the bone-bed, though it appears at Hagley, not far off, and at other places surrounding the Woolhope elevation.

March 24, 1869.

The Rev. Samuel Norwood, B.A., Head Master of the Royal Grammar School, Whalley, Lancashire, was elected a Fellow of the Society.

The following communications were read:—

1. *The* Cretaceous Strata *of* England *and the* North *of* France *compared with those of the* West, South-West, *and* South *of* France, *and the* North *of* Africa. By Prof. Henri Coquand, Marseilles.

[Translated and communicated by J. W. Flower, Esq., F.G.S.]

English geologists may fairly claim the honour of having established in the Cretaceous formation the great divisions which are now generally received, and which find on the European continent their direct application to the strata of the same period. This is more especially true as regards the basin of the Seine, which is in fact but an appendage of that of England.

When, however, we leave the valley of the Seine and approach the Departments of the west of France, we find that the divisions previously recognized become altogether insufficient. For example, between the first beds with *Inoceramus labiatus* (the base of the Lower Chalk) and the highest layers of the chalk marl (with *Ammonites Mantelli*), some important beds of sandstone and limestone, characterized by *Ostrea biauriculata*, Lamk., intervene. These beds are known by the name of the *Grès du Mans*, and they seem to be wanting in England, as also in the north of France.

If from the Anglo-Parisian basin we pass to that of the Pyrenees, of which the Departments of the two Charentes and the Dordogne constitute the northern limits, at least in a geological point of view, we meet with still more important modifications. Thus, the Grès du Mans are here more highly developed, and force themselves upon the notice of the palæontologist on account of the great abundance of Rudistes which they contain, such as *Sphærulites foliaceus*, Lamk., *Caprina adversa*, C. M. D'Orb., *Caprina Fleuriausii*, *Monopleura polyconilites*, &c. Above this layer, of which the Oyster-beds (*Ostrea biauriculata*, Lamk., and *Ostrea flabella*, D'Orb.) invariably form one of the constituents, are the marly beds of the Lower Chalk with *Inoceramus labiatus*, a stratum which in England and in Picardy comprises in its upper portion the layers with *Ostrea acuti*-

rostris, *O. frons*, Park., and *Spondylus truncatus*; whilst in the south-west and the south these latter beds are separated from the horizon of *Inoceramus labiatus* by the entire thickness of the Angoumian, Mornasian, and Provencian stages (which in some places is not less than from 550 to 600 metres, equal to from 1825 to 2000 feet), and therefore by three distinct faunas.

Inoceramus labiatus is there accompanied by *Ammonites rusticus*, Sow., *peramplus*, Sow., *navicularis*, Sow., and *Woollgari* (Mant.), *Terebratella carentonensis*, &c. The superposition of the two stages is visible on the sides of the plateau on which the town of Angoulême is built, the cornice of the plateau itself being formed by a thick bed of solid limestone, much used for building-purposes, and abounding in *Radiolites lombricalis*, D'Orb., and *R.* (*Hippurites*) *cornu-pastoris*, Desmoulins.

Here we have another new horizon, unknown, or at most only suspected to exist, in the basin of the Loire, and which in its turn bears still more important strata of another solid kind of limestone, of which the differential fauna is represented by *Hippurites organisans*, Desmoul., *H. cornu-vaccinum*, Bronn, and *Sphærulites Sauvagesii*, D'Homb.

With this Hippurite limestone in the south-west and the south of France terminates that which I have designated by the name of *Craie moyenne*, and which, with the sandstone of Uchaux and the limestone with *Radiolites lombricalis*, separates the beds with *Inoceramus labiatus* from those with *Spondylus truncatus*, Lamk., *Lima Hoperi*, Sow., and *Micraster laxoporus*, D'Orb.

The Upper Cretaceous is composed of 4 stages:—

1st. Sandstones and sandy limestones, with *Rhynchonella Baugasii*, D'Orb.

2nd. Marly glauconite limestone, with *Ostrea auricularis* (Brongn.) (*Gryphæa*), *O. frons* (Park.), *O. santonensis*, D'Orb., *Spondylus truncatus*, Lamk. (*Podopsis*), *Micraster cor-testudinarium*, Agassiz, and *cor-anguinum*, *Radiolites fissicostatus*, D'Orb., and *Sphærulites Coquandi*.

3rd. White chalky limestone, with *Ostrea vesicularis*, Lamk., *O. larva*, Lamk., *O. laciniata*, D'Orb., *Ananchytes ovatus*, *Sphærulites Hœninghausii*, Desml., *Radiolites crateriformis*, Desml., and *Hemipneustes radiatus*, corresponding with the chalk of Meudon and the Upper Chalk, and forming the hills round Cognac, which produce the best brandy in the world.

4th. Solid yellow limestone in the Department of the Dordogne, with *Faujasia Faujasii*, D'Orb., *Hippurites radiosus*, Desml., *Sphærulites cylindracea*, Desml., and *Radiolites ingens* and *Bournoni*, D'Orb., corresponding with the highest portion of the Maestricht Chalk.

In the explanatory text of the Geological Map of the Charente which I have prepared *, I have divided the Cretaceous formation of the south-west in the following manner, beginning from the Gardonian stage, with which it commences (see fig. 1):—

* Coquand, Descript. Géol. et Pal. de la Charente, vol. i. 1858.

MIDDLE CRETACEOUS.

1st. Rhotomagian stage (*Turrilites costatus,* Lamk.), wanting.			
2nd. Gardonian stage, with lignites		6	metres.
3rd. Carentonian stage	(*a*) Lower portion, with *Sphær. foliaceus* and *Ostrea biauriculata* ("Bancs à Ostracées" de M. d'Archiac)	67	,,
	(*b*) Upper portion, with *Inoc. labiatus* and *Amm. rusticus* (base of the chalk marl and lower chalk)	25	,,
4th. Angoumian stage, with *Radiolites lombricalis* (wanting in England)		40	,,
5th. Provencian stage, with *Hippurites organisans,* Desml. (wanting in England)		37	,,
		175	,,

UPPER CRETACEOUS.

1st. Coniacian stage (Grès de Cognac) (wanting in England)	40	metres.
2nd. Santonian stage (of Saintes) (superior Lower Chalk = chalk-marl, upper part)	65	,,
3rd. Campanian stage (Champagne de Cognac = Upper Chalk)	70	,,
4th. Dordonian stage (wanting in England)	15	,,
	190	,,

These divisions, which are perfectly well marked and of considerable thickness, and possess peculiar faunas and composition, evidently differ very much from what we may observe in the basin of the Seine and in England, where we pass directly from the chalk marl (Rhotomagian stage) to the Lower Chalk, and thence to the Upper Chalk without the intervention of the Carentonian, Angoumian, Provencian, and Coniacian stages.

The coast of Provence, however, presents a still more gigantic development of the Cretaceous formation (see fig. 2), and such material differences from what is met with elsewhere, that in order perfectly to understand the connexion which exists between the system of the south and that of the north of France, an intimate knowledge of the localities is necessary, and the help of fossils is indispensable. And here I may appeal to those English geologists who have had the opportunity of examining our strata.

Without speaking of the Neocomian strata, the lower greensand, with *Diceras Lonsdalii,* the Speeton clay, and the gault, which do not offer any very striking peculiarities, I shall pass at once to the middle and to the upper Cretaceous beds, briefly describing their composition, and their equivalents in England.

It may perhaps be advisable, on account of its fauna and difference of position, to separate the upper from the lower part of the Carentonian stage, and to form for it another stage, which I shall propose to call the *Ligerian.* This will have the advantage of giving to the beds with *Inoceramus labiatus* an autonomy of their own, and will prevent their being confused, as they must be in the basin of the Loire and in England, with the limestones of the same colour which succeed them without the interposition of the intermediate stages which separate them in Provence, and which contain completely different faunas.

Fig. 1.—*Section of the Cretaceous Beds of the Charente*.*

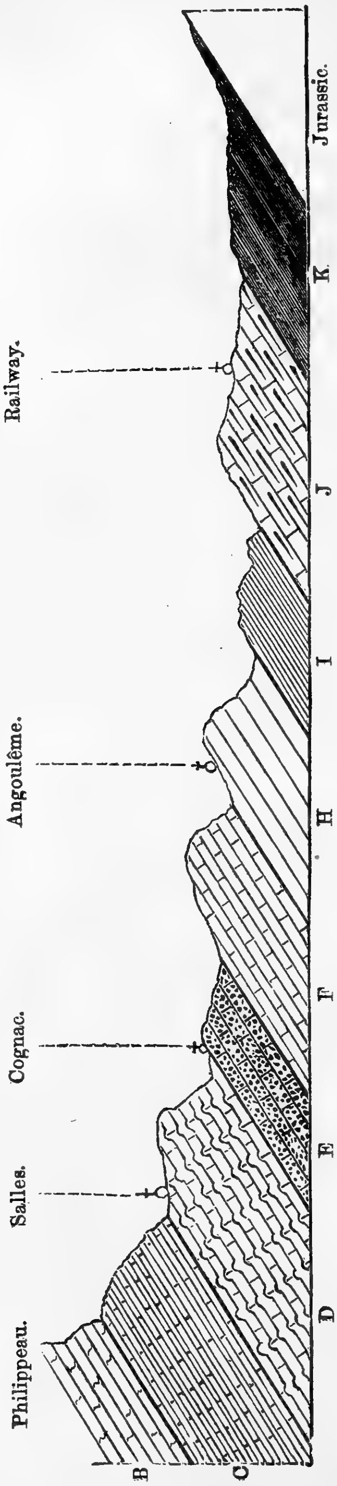
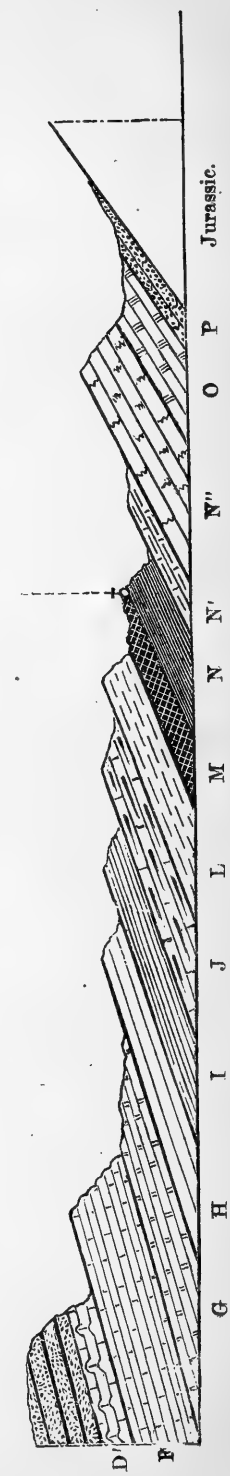


Fig. 2.—*Section of the Cretaceous Beds of the coast of Provence between Le Beausset and Marseilles.*



* For explanation of diagrams and general table of stages see p. 246.

MIDDLE CRETACEOUS.

1st. Gault, with *Amm. cristatus, lautus, Raulinianus*			22	metres.
2nd. Rhotomagian stage.	Lower beds	with *Amm. auritus, planulatus, rostratus, Pecten asper,* &c.; ("Etage Uraconien" of M. Renevier; Cambridge Greensand)	35	„
	Upper beds	with *Turrilites costatus, tuberculatus, Bergeri, Puzosianus, Scaphites æqualis, Ammonites Mantelli, rhotomagensis, varians, sulcatus, Mayorianus, Velledæ, Renauxianus, Belemnites ultimus, Janira quinquecostata, Avellana cassis,* and *Radiolites Mortoni*	40	„
This stage corresponds to the upper greensand and the chalk marl.				
3rd. Gardonian stage, chalk-marl beds of fluvio-marine origin, with *Cyrena, Potamides,* and *Ostrea vardonensis,* Coq., containing several beds of lignite, which are worked in the Departments of the Gard and Vaucluse			75	„
4th. Carentonian stage	Lower portion	with *Sphærulites foliaceus, Caprina adversa, Ostrea flabella, O. biauriculata,* and *Heterodiadema libycum* (wanting in England)	40	„
	Upper portion	with *Inoc. labiatus, Amm. peramplus, A. Woollgari* (Mant.), *A. navicularis, A. rusticus,* and *Hemiaster Verneuili,* Desml.	160	„
5th. Angoumian stage, compact limestones, with *Hipp. Requienianus,* and *Radiol. cornu-pastoris* (wanting in England)			60	„
6th. Mornasian stage, alternate clays and sandstones, with *Amm. Requienianus* (wanting in England)			250	„
7th. Provencian stage, compact limestone, with layers entirely composed of *Hipp. organisans, H. cornu-vaccinum, Sphærulites Sauvagesii, S. Desmoulinsii,* and *Caprina Coquandiana,* La Cadière, Martigues; base of the chalk of Gosau; wanting in England)			120	„
			802	„

Notwithstanding some very striking points of resemblance between the middle chalk of the two Charentes and that of the south of Provence, we find that the latter differs from the former in many important particulars. In the first place, it possesses the stages of the gault and upper greensand, which are wanting in the other; further, the beds with *Inoceramus labiatus* are more than 500 feet in thickness; and, lastly, between the Angoumian and Provencian stages there intervenes, especially in the Department of the Bouches-du-Rhône (between La Cadière and La Ciotat), a stratum of sandstone of which there are no traces in the Departments of the south-west, and which is remarkably rich in fossils in the Communes of Uchaux and Mornas. But the most important modifications must be made in the upper chalk, which is subdivided in the following manner:—

THE UPPER CRETACEOUS.

1st. Coniacian stage: Ferruginous sandstone, with *Ostrea auricularis* (Brong.) in the neighbourhood of Piolenc.

2nd. Santonian stage: the lower part with *Ostrea acutirostris*, *O. santonensis*, *Spondylus truncatus*, *Janira quadricostata*, *Sphærulites Coquandi*, and *Radiolites fissicostata*.

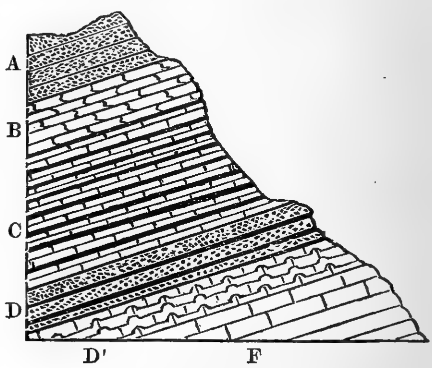
The upper part, of fluviatile origin, with *Unio*, *Cyclas*, *Omphalia Coquandi* (Zekeli), and 7 beds of lignite, *Cyrena globosa* and *Ferussaci*, Math., *Melanopsis rugosa*, Math., and *M. gallo-provincialis*.

Plan d'Aups, near Sainte Baume, and the environs of Martigues.

This corresponds to the upper portion of the chalk of Gosau.

3rd. Campanian and Dordonian stages, from 400 to 500 metres, equal to from 1333 to 1666 feet, of Lacustrine limestones, with *Cyclas gardanensis*, *Brongniartina*, and *gallo-provincialis*, Math., *Ampullaria proboscidea*, Math., *Paludina angulata*, Math., *Lymnea longissima*, Math., &c., and containing 18 layers of lignites, very different from those which are worked lower down, in the Santonian stage (fig. 3). It is evident that these Lacustrine limestones correspond with the "Upper Chalk" and with my Dordonian stage; for they are covered by other Lacustrine limestones, which are referred to the level of the limestone of Rilly, and therefore to the base of the Eocene.

Fig. 3.—*Section of the Freshwater Upper Cretaceous Beds of Fuveau.*



Thus in Lower Provence it is evident that a complete change must have been wrought in the nature of the waters of the Cretaceous Sea, which, after the conclusion of the Santonian period, from being salt became brackish, and afterwards, from brackish, fresh—a circumstance which favoured the development of a population of fluviatile shells, entirely unknown elsewhere, and which were contemporary with the gigantic Rudistes of the Charente, and those of Provence, which lived in the immediate vicinity of the lake, at the bottom of which the Carbonaceous deposits were precipitated.

The classification of these Lacustrine sediments had been, until very lately, the cause of great confusion and serious errors. They had been attributed at one time to the Miocene period, at another to the Eocene, without a single reliable argument, or a single fossil in support of this opinion. The new method of determining their chronological order is justified, not only by their position, but also by the very important fact that in the neighbouring Alps, as well as in Algeria, where the upper chalk is exclusively of marine origin, we observe, above the Santonian strata, *Ostrea vesicularis* and *Belemnitella mucronata*, species wanting in the corresponding strata of the Bouches du Rhône, which, as we have seen, having been deposited in a lake, can only contain Lacustrine shells. My friend M. Matheron is occupied at the present time in making out a catalogue of this interesting fauna, which comprises a large number of species, all peculiar to the limited country of which we are speaking. It is necessary, therefore, to admit that there is a Wealden in the Upper as well as in the Lower Chalk.

The repeated alternations which have taken place between truly marine and fluvio-carbonaceous deposits, is a fact well worthy of notice in the history of the Cretaceous formation of the Mediterranean coast. Thus we have ascertained* that the great accumulations of combustible matter of the Province of Ternel, in the Kingdom of Arragon, belong to the Aptian stage. In the Department of the Gard, and at Mondragon, the coal worked belongs to the Middle Chalk. At Sainte Baume† the Provencian limestones contain jet with amber, which has been the object of some research. Lastly, the great industrial works which supply the market of Marseilles with coal are opened in the Santonian and Campanian stages, stages which, in the counties of Kent and Sussex, as well as in the environs of Paris, are remarkable for the purity and whiteness of the chalk of which they are composed.

It would be not merely dangerous, but impossible, to establish a comparison upon the petrographic character of countries distant from each other, since our chalk in the south only furnishes hard limestones employed in large building-works, sandstones with which the streets of Marseilles are paved, black limestone, black clay and coal. But, in spite of this difference in the composition of the rocks, there exists a principle which furnishes a sure means of establishing comparisons, in which mineralogy cannot assist. This principle lies in the examination of the faunas. Thus, although England is deprived of the legion of Rudistes which have rendered the chalk of our country so celebrated, she nevertheless possesses a considerable quantity of fossils identical with ours, by means of which it becomes easy to establish strict synchronisms for the corresponding stages, just as it is easy to show that the chalk of Provence is much more complete than that of Great Britain and the basin of the Seine. Whence I conclude that, if a general classification of the Cretaceous formation were now to be attempted by an international Geological Congress, the preference ought to be given to Provence, on account of the facility of finding there larger and more numerous divisions—in one word, more classical types.

To any one acquainted with the mountains of Provence, the geology of Algeria offers no very serious difficulty. The Cretaceous formation of the elevated plateaux of the Atlas seems to have been copied from Provençal models (fig. 4). Above the Lower Greensand and the Speeton Clay, we find the same succession of stages as in the south of France; but they are generally richer in fossil species, especially in *Ostreæ* and Echinoderms.

* Monographie Paléontologique de l'étage Aptien de l'Espagne, 1862.
† Description Géologique du Massif Montagneux de la Sainte Baume, 1866.

The following are the divisions which we have recognized* :—

MIDDLE CRETACEOUS.

1st. Gault, with *Amm. Velledæ, Beudanti, mammillaris, Roissyanus, versicostatus*, and *Solarium ornatum*.

2nd. Rhotomagian stage, with *Amm. Mantelli, varians, rhotomagensis, Scaphites æqualis*, and *Turrilites costatus*.

3rd. Carentonian stage. Base with *Ostrea flabellata*; upper part with *Inoceramus labiatus, Pseudodiadema libycum*, and *Ammonites Woollgari* (Mant.). (Lower chalk, Ligerian stage, Coq.).

4th. Angoumian stage, with *Radiolites lombricalis* and *cornu-pastoris*.

5th. Mornasian stage, marly, with *Amm. Requienianus*, and *Trigonia scabra*.

6th. Provencian stage, with *Hippurites organisans*.

This middle chalk is very admirably developed in the environs of Tébessa, and in the neighbouring Tunisia, as well as in the environs of Batna.

UPPER CRETACEOUS.

1st. Santonian stage, with *Ostrea auricularis, Ostrea acutirostris, Lima Hoperi, Ostrea proboscidea*, D'Arch., *Ostrea hippopodium, Ostrea santonensis*, and *Micraster cor-anguinum*.

2nd. Campanian stage, with *Ostrea vesicularis, Ostrea pyrenaica*, Leym., *Ostrea larva, Ammonites texanus*, Röm., and *Inoceramus Crispii*, Mant.

3rd. Dordonian stage, with *Radiolites Jouanneti*, and *Hippurites radiosus*, Desml.

These divisions correspond exactly to those which we have met with in Lower Provence†.

When we consider that the long series of fossils described as peculiar to Algeria, and belonging exclusively to the middle and to the upper cretaceous, has been collected by only a few individuals, we shall readily understand that future researches must very extensively increase their number. Indeed, since the publication of my work

* Description Géologique et Paléontologique de la région sud de la Province de Constantine, 1862.

† The author here gives a complete list of the species of fossils recognized by him as peculiar to the Algerian beds. These are arranged under their different stages, and their numbers are as follows:—

1. Gault	6	species
2. Rhotomagian	118	,,
3. Carentonian	31	,,
4. Mornasian	38	,,
5. Provencian	10	,,
6. Santonian	46	,,
7. Campanian	22	,,
8. Dordonian	5	,,
Total	276	,,

As these species are cited from his work on the Geology and Palæontology of the Province of Constantine, a list of their names would be equally useless to those who do, and to those who do not, possess that work.

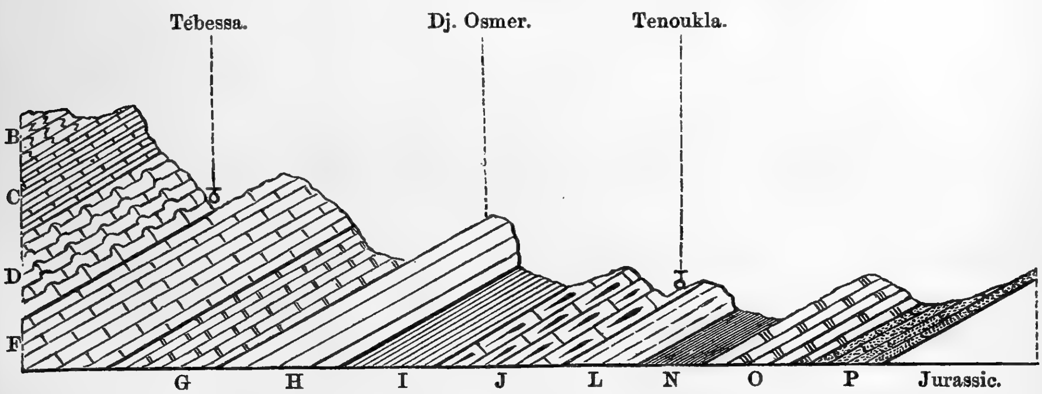
on the Geology of Constantine, I have received from M. Brossard several unpublished species; and M. Peron, who has intelligently explored the high plateaux of the provinces of Algiers and Constantine, has in his possession a great quantity of new materials, which he intends to make known, and which must certainly be very important, judging from the large quantities of *Ostreæ* which I have received from him for a publication upon which I am now engaged. In the chain of the Madonies in Sicily, I was able to recognize the Rhotomagian type of the environs of Tébessa, represented by identical fossils of the same colour (*Ostrea syphax, Ostrea africana, Ostrea Overwegi*, Coq.). M. Seguenza also discovered the Rhotomagian stage in the Province of Reggio, in Calabria. We know that it exists in the Lebanon, and in the desert which separates the Dead Sea from the Red Sea.

From the foregoing details it appears that, should we continue to take the English divisions as a frame-work for the general divisions of the chalk, we shall find it insufficient to contain the enlarged canvas.

We have indeed seen that beyond the basin of Paris the chalk of Mans is increased by a new stage (the Carentonian), the chalk of the west by three stages (the Angoumian, Provencian, and Dordonian), and the chalk of Provence by the Mornasian stage.

If we now endeavour to draw conclusions from the resemblance or identity of the faunas, we shall see that, in addition to the fossils which are common to all, and which form useful landmarks in the field of discovery, each region possesses species peculiar to itself; so that if we were to compare two extreme points, as, for example, Algeria and England, without taking into account the intermediate localities, we should be so struck by the great dissimilarities as to ask ourselves whether we are not comparing two different formations.

Fig. 4.—*Section of the Cretaceous Beds of Algeria.*



But if we compare Algeria with Provence, Provence with the Charente, the Charente with the Sarthe, the Sarthe with Paris, and Paris with England, we recognize, without any surprise or shock, the connecting links which unite the scattered particles into a whole, and we perceive that, as regards the faunas, and the development and number of the strata, the transitions are made insensibly. If, instead of adhering in this case to observations made step by step, we were to take long strides, and if from any part of Europe we were suddenly to find ourselves in India or in the United States of America, we should meet with much more embarrassing gaps.

I must not, however, forget to add that, in spite of very important differences, there exist, both in India and in the United States, a certain number of fossils which may be called *characteristic* in the highest degree, which are found everywhere at the same level, and which allow us to place the entire fauna in its proper arrangement, —whence we come to the conclusion that it would be illogical, as regards palæontological stratigraphy, to consider any given country an obligatory and inflexible term of comparison, and to refer to it the formations of other countries. This would be to wish to establish arbitrarily a sort of bed of Procrustes, which would place us under the necessity of stretching or mutilating our subjects at every moment, in order that we might always obtain the same measurements.

It appears more reasonable to look at things from a higher point of view, and to regard a formation with its stages as a confederation composed of a variable number of cantons, united by common ties, rather than as a people springing from the same source, speaking the same language, and governed by the same laws and the same formulæ.

TABLE OF STRATA AND EXPLANATION OF THE DIAGRAMS.

I. Upper Cretaceous.

A. Red lacustrine limestone of Vitrolles (*Étage Garumnien* of Leymerie).
B. Dordonian Stage. Freshwater at Fuveau with *Lychnus*. Marine in the Charente and Algeria.
C. Campanian Stage (=Upper Chalk). Freshwater at Fuveau with seventeen beds of coal; elsewhere marine.
D. Santonian Stage (=Superior Lower Chalk). Upper part, freshwater at Fuveau.
E. Coniacian Stage (Sandstone).

II. Middle Cretaceous.

F. Provencian Stage (with *Hippurites*).
G. Mornasian Stage (Uchaux Sandstone).
H. Angoumian Stage (*Radiolites cornu-pastoris*).
I. Ligerian Stage, with *Inoceramus problematicus* and *labiatus*. (=Inferior Lower Chalk.)
J. Carentonian Stage, with *Ostrea biauriculata* and *Sphærulites foliaceus*.
K. Gardonian Stage (lacustrine, with coal).
L. Rhotomagian Stage, with *Turrilites costatus* (=Upper Greensand and Chalk Marl).
M. Gault.

III. Lower Cretaceous.

N. Upper Aptian Stage (=Argiles à Plicatules=Speeton Clay).
N′. Middle Aptian Stage, with *Orbitolites lenticularis* } (=Lower Greensand).
N″. Lower Aptian Stage (=Vigonian) }
O. Neocomian Stage, with *Spatangus retusus*.
P. Valongian Stage, with *Natica Leviathan* (=Weald).

Discussion.

Mr. J. W. Flower called attention to the great discrepancy between the thickness of the Cretaceous beds of the south of France and those of England, the former being four times the magnitude of the latter. This was principally made up by several strata entirely wanting in England, and for the most part of a totally different character, being either of freshwater origin or else hippurite limestone. Another great feature of distinction was the presence of coal-bearing beds with numerous layers of lignites. That these beds were of Cretaceous origin was proved by their occurrence under undoubted Eocene beds. Among the fossils of the Algerian chalk were those of several genera unknown in the Cretaceous beds of England.

Dr. Duncan suggested that possibly the Upper Coal-beds might be the equivalents of those of Aix-la-Chapelle. He doubted whether any decided synchronism in strata spread over so extensive an area as that of the Cretaceous deposits could be established by the mere occurrence of certain fossils in them; nor could he attach much value to supposed specific differences in shells of such character as *Ostrea*. The variations in condition in the sea-bottom would lead to variations in the Testacea; and there were signs to be found of great variations going on before the form of *Hippurites* was developed. He regarded *Hippurites* as a modified form of *Chama* or *Caprina*, and thought it was parasitic on coral reefs in the same way as its modern representative. He accounted for its presence by the great development of corals at that period in the Cretaceous seas.

Mr. Judd remarked upon the repeated changes which had occurred in the opinions of foreign geologists as to the limits of the various "stages" into which the Cretaceous rocks might be divided, and indicated that this of itself was equivalent to the abandonment of the principles laid down by D'Orbigny. He further observed that in the recent changes, even as evidenced by M. Coquand's paper, there was a tendency to approach the views as to the classification of the Cretaceous beds established by the late Prof. Edward Forbes, and generally accepted by English geologists.

Prof. Morris observed that the object of the French geologists had been to remove the opinion that mere mineralogical characters were sufficient to distinguish Cretaceous strata. He called attention to the existence of copper and antimony in some of the Lower Cretaceous beds, and to the great break that appeared to exist between the Lower and Middle Cretaceous series. Another curious point was that in the south of France there appeared to be passage-beds between the Upper Cretaceous and Eocene beds.

Prof. T. Rupert Jones remarked on the analogy between the passage from the Chalk to the Eocene Tertiaries, as supposed to be exhibited in the south of France and in the Nebraska territory of America. He pointed out that as the Cretaceous beds of France had been deposited, not in one sea, but in separate sea areas, they were, of course, difficult of correlation.

2. *On the* Structure *and* Affinities *of* Sigillaria *and* allied Genera. By W. Carruthers.

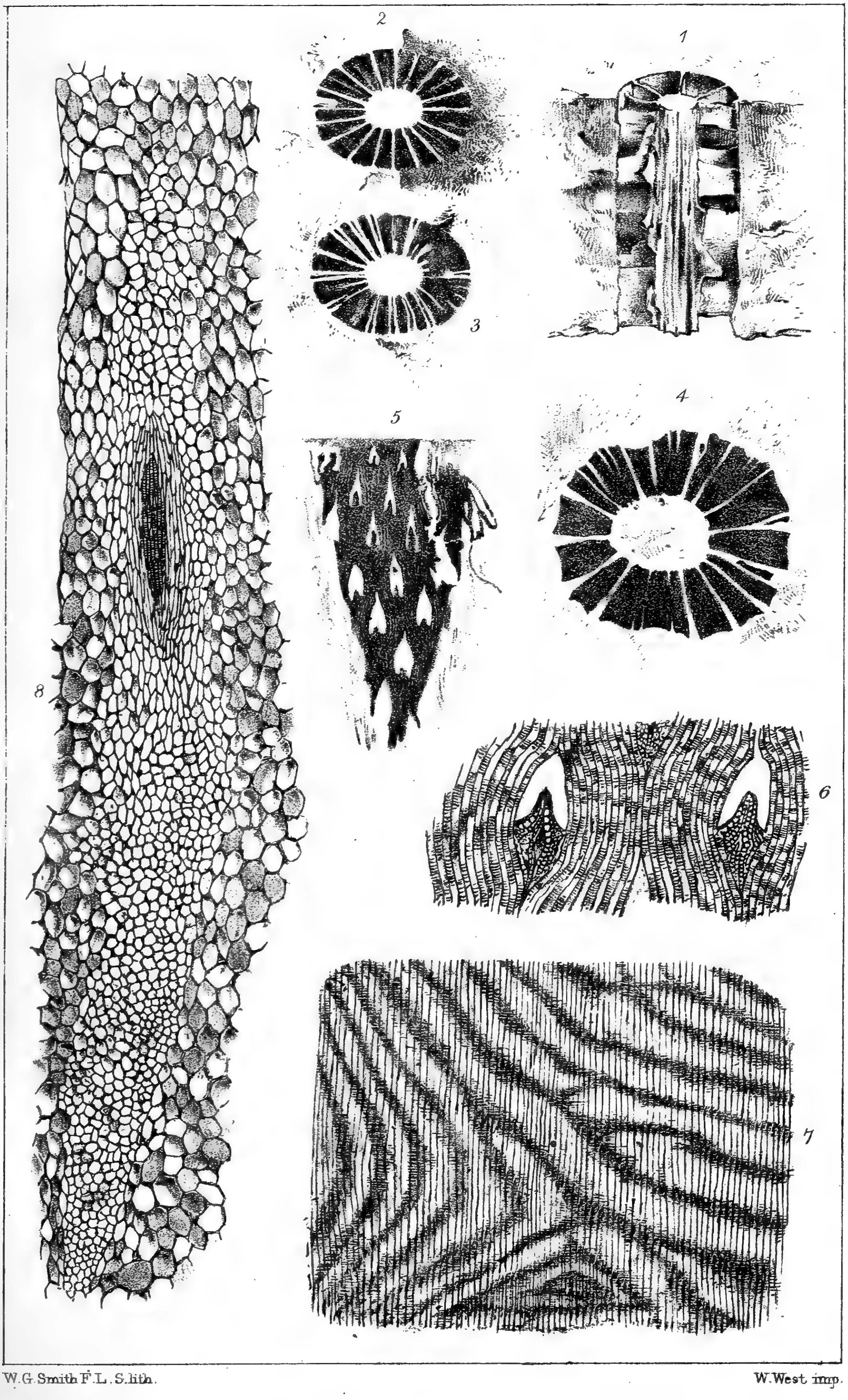
[Plate X.]

The genus *Sigillaria* is one of the most abundant and important among the plants of the Carboniferous period. But, except that it was a large tree with a fluted and scarred stem, and had immense succulent roots, little is certainly known regarding it. The structure of the root is well known, having frequently formed the subject of investigation. Numerous specimens of stems have been published, as examples of the genus; but with the exception of that described by Brongniart under the name of *Sigillaria elegans*, they belong rather to the genus *Lepidodendron*; and even *S. elegans* does not represent the most characteristic form of the genus. The stem was most probably simple, though in some species it was certainly branched. The foliage in some forms was composed of long linear leaves; and Goldenberg has figured organs of reproduction in the form of small round sporangia, several of which were borne on the somewhat dilated bases of the leaves at the termination of a branch.

The affinities of the genus have chiefly been deduced from the structure of the stem and roots; and in accordance with the views taken by the different interpreters has been the place they have given it. Some, like Corda and Martius, have held it to be a polypetalous dicotyledon, while, on the other hand, Dr. Hooker, with a little hesitancy, places it among *Lycopodiaceæ* beside *Lepidodrendron*. The generally received opinion is somewhat intermediate, that it is a gymnosperm belonging to an extinct type. Brongniart first enunciated this view; and it has been subsequently maintained by Göppert, Unger, &c., and recently by Dawson in an important and elaborate paper on the Coal Formation of Nova Scotia, published in the Journal of this Society in 1866, and two years later in his 'Acadian Geology.'

I propose to investigate shortly the grounds upon which these eminent palæontologists have given this position to the genus, and how far their interpretations agree with the actual structure of the plant.

I shall first consider the structure of the root, the relation of which to the stem has been established beyond question. The investigations of Mr. Binney on the external form and of Prof. King and Dr. Hooker on the internal structure make it unnecessary that I should describe at any length the root so well known by the name of *Stigmaria*. The general structure may be given in a few words. It was a thick root having a medulla of considerable size, surrounded by a cylinder of scalariform vessels; and this again was invested by a large mass of cortical parenchyma. From numerous pits on the outer surface of this cortical layer proceeded the long cellular rootlets, each furnished with a small bundle of firm scalariform vessels that had its origin in the vascular cylinder. In the arrangement of the parts, and in the general aspect of a transverse section of the stem, it agrees with the structure of the stems of *Cycadeæ*, and of the fleshy *Euphorbiaceæ* and *Cacteæ*. It is unnecessary to say that



W. G. Smith F. L. S. lith.

W. West imp.

STRUCTURE OF SIGILLARIA.

mere analogical resemblances give no assistance in determining systematic position, but rather tend to lead astray, as they have done in the genus in question. There is one point in which the fossil differs from the living plants, which must at once, if it can be established, separate them widely in systematic position. I refer to the absence of medullary rays in the vascular cylinder of *Stigmaria*. This cylinder is composed entirely of scalariform tissue pierced only by meshes for the passage from the inner surface of the cylinder of the vascular bundles that supply the rootlets.

It is important to remember that medullary rays are composed entirely of muriform cellular tissue, and keep up the connexion between the internal and external cellular structures—the pith and bark. Medullary rays are confined to and characteristic of exogenous stems. They break up the wood into innumerable fine meshes. But, besides these, there are in exogenous stems other and larger meshes for the passage outwards of the vascular bundles which supply the axial appendages—the leaves and branches. In some stems, as in *Phytocrene*, *Tupa*, *Cycas*, *Euphorbia*, *Cactus*, &c., from the size of the vascular bundles these meshes are very large; but in ordinary trees those formed by the leaves early disappear, because, the leaves being deciduous and produced only on the younger portions of the tree, the vascular bundles supplying them are not continued through the whole woody cylinder. It is of the utmost importance to notice these two sets of horizontal radiating structures in the dicotyledonous stem—the one, entirely cellular, being the medullary ray, the other, vascular, being the vessels of the axial organs.

Among recent cryptogams the only plants which have anything like a continuous woody cylinder in their stems are the Ferns. In the *Lycopodiaceæ* and *Equisetaceæ*, as represented among living plants, the vascular bundles of the stem are symmetrically arranged in a large mass of parenchyma, and there is consequently no true separation between the cellular tissue of the medulla and that of the cortical layer. It is however different in many tree ferns, which are composed of a mass of parenchyma traversed by vascular bundles of scalariform tissue, which form a closed circle separating the medulla in the interior from the cortex of the exterior. The tissue of this vascular cylinder is entirely destitute of medullary rays; but it is penetrated by large meshes, through which pass the vascular bundles that supply the fronds and invariably rise from the inner surface of the cylinder.

The trunk of the cryptogam differs from that of the dicotyledon, as regards the points in question, in having its vascular cylinder penetrated by only one kind of horizontal tissue, namely, the vascular bundles belonging to the fronds, while the exogenous stem has, besides, another horizontal tissue of a very different structure and performing a totally different function.

The woody cylinder of *Stigmaria* possesses only the vascular horizontal layer; but from not distinguishing aright these two structures, this has been described as a medullary system. Where a medullary ray has been described in addition to the vascular system, it has arisen from some error of observation. I exclude from this the specimen figured by Cotta under the name of *Stigmaria ficoides*, the vascular tissue of which is composed of Cycadian-like or of dotted vessels traversed by muriform cells of medullary rays; for this is certainly not a specimen of *Stigmaria*.

Brongniart, in his memoir on *Sigillaria elegans*, figures a specimen of *Stigmaria* from the cabinet of Robert Brown, which is now in the collection of the British Museum, and which I have repeatedly and carefully examined. In an enlarged representation of a portion of the cylinder (pl. v. fig. 3) there is shown an axial vascular bundle passing outwards through a mesh between the large wedges of the cylinder. Several open spaces separating the parallel series of vessels on the outer aspect of the cylinder are described as small medullary rays; but the examination of this and of an extensive series of other specimens has convinced me that these are only disruptions of the tissue produced along the line of least resistance from desiccation or some other cause before or during the process of fossilization. Brongniart was unable to detect any remains of structure in these spaces. Such openings are altogether absent in many specimens which I have examined; and in one in the collection of the British Museum they occur on the one half of the specimen and not on the other.

Dr. Hooker, in his paper on the structure of *Stigmaria*, makes no reference to the small cellular medullary rays of Brongniart, which he evidently could not detect in his specimens, and which are not indicated in the least in his beautiful drawings. He, however, describes structures to which he applies the name of medullary rays. "The cylindrical axis," he says, "is divided into elongated wedge-shaped masses, rounded at their posterior or inner extremity by numerous medullary rays of various breadths, some much narrower than the diameter of the tubes, others considerbly broader, but none are conspicuous to the naked eye, except towards the outer circumference. The medullary rays, even the narrowest, are traversed by bundles of tubes half the diameter of the largest vessels of the axis, or even less" (p. 434). In the explanation of plate ii, fig. 6, he further says, "The vascular tissue is divided by broad and narrow medullary rays;" and fig. 8 is a "highly magnified view of one of the narrow medullary rays forming a bundle of tubes of less diameter than those forming the wood." The structures described in these extracts are evidently the vascular bundles which belong to the axial appendages. These bundles take their origin in the inner surface of the vascular cylinder, and pass upwards and outwards through a mesh, which increases in size as it reaches the circumference of the cylinder. The vascular bundle did not completely fill the mesh, but was accompanied by a quantity of cellular tissue which is very rarely preserved, the space occupied by it being generally filled with the amorphous material of the matrix in which the specimen is preserved. This parenchyma is composed of roundish cells. In the fern-stem a similar structure exists. The vascular tissue of each frond has a parenchyma associated with it which is continuous with the medulla.

The absence, then, of any true medullary ray excludes the *Stigmaria* from the Dicotyledons, and places it beyond doubt among the Cryptogams; and this is further confirmed by the fact that the whole of the vascular tissue is composed of scalariform vessels, which are not known to make up the whole of the vascular tissue of any plants except among the Cryptogamia.

As the internal structure of the root is the same as that of the stem, we ought to find in the latter an absence of true medullary rays, and the existence only of a vascular horizontal system communicating with the axial appendages.

Brongniart's elaborate memoir on *Sigillaria elegans* still supplies the most detailed account of the internal structure of the stem of this genus. It consists of a central cellular axis, or medulla, surrounded by a vascular cylinder; and this, again, is invested by a thick cellular cortical layer, the outer portion of which is composed of fusiform cells of less diameter than those of the inner portion. So far this is precisely what is found in *Stigmaria*; but the vascular cylinder is, according to Brongniart, broken up by numerous delicate medullary rays, whose tissue, however, is destroyed. He was unable to detect the least trace of the cells; yet he assumes without any hesitation or doubt that the openings between the radiating lines of the vascular tissue are certain indications of medullary rays, and points out that the difference between *Lepidodendron Harcourtii*, which Lindley and Hutton had described, and his own *Sigillaria elegans* lay entirely in the possession of medullary rays by his plant. When, however, the figures of Brongniart are compared with the numerous specimens which have been discovered since, many of which have been figured, and especially with those published by Binney under the name of *Sigillaria vascularis* (which, however, are species of *Lepidodendron*), it is easy to see that he wrongly interpreted the series of cracks in the small fragment he was examining, just as I have shown he did in Robert Brown's specimen of *Stigmaria*. The beautiful longitudinal section cut parallel to the supposed medullary rays (pl. iii. fig. 2) is without any trace of the muriform structure; and it ought to have been seen here if it ever existed. The supposed ends of the medullary rays shown in fig. 203 of plate iv. are much more like the results of desiccation or decay than the sections of rays; and the aspect of the adjoining scalariform vessels does not agree with what would have been produced by a medullary ray upon the vascular tissue forming the margins of the mesh through which it passes.

Brongniart's interpretation of these spaces is repeated by him in his 'Tableau,' and is adopted by all subsequent writers. It forms the real difficulty in the way of Dr. Hooker's referring without hesitation the genus to *Lycopodiaceæ*.

In Dr. Dawson's valuable contribution to our knowledge of the Coal-flora, he describes the medullary rays as existing in *Sigillaria*, in addition to the vascular bundles belonging to the axial appendages; but neither in his letterpress nor his plates can I determine whether this arises from the already adopted diagnosis of the genus, or is the result of his independent observations. Binney obviously confuses the two kinds of horizontal structures when he speaks throughout his papers of medullary rays composed of "finely barred vessels." He neither figures nor describes any true medullary ray; and it is certain from his drawings that they do not exist. This I have moreover established by the examination of numerous beautifully preserved specimens.

If, then, I am right in believing that the structureless spaces in the vascular cylinder of *Sigillaria elegans* do not represent medullary rays, the structure of the stem exactly agrees with that of the root. This is, moreover, precisely the structure of *Lepidodendron*, *Halonia*, *Ulodendron*, &c., so that I venture to refer, without any doubt, all these genera to the same great group of extinct arborescent *Lycopodiaceæ*.

Dr. Dawson describes the vascular cylinder of *Sigillaria* as much more complex than anything I have seen. He says it was double, the inner portion being composed of scalariform, and the outer of discigerous vessels. He has figured a specimen of a stem in which the two kinds of tissue exist together. The important discigerous tissue could not be altogether wanting in Brongniart's specimen if it were really a constituent part of the Sigillarian stem, even though, as Dr. Dawson suggests, it were a young stem or branch *.

* Since writing the above I have had, through the kindness of Sir Charles Lyell, the privilege of examining Mr. Dawson's specimen of the *Sigillaria* figured in plate 17, vol. xv. of the Society's 'Quarterly Journal,' and which has supplied him with the data for his interpretation of the internal structure of the genus. It is unnecessary for me to say that the specimen is accurately figured and described; but it yet appears to me more than doubtful that it belongs to *Sigillaria*. The fact that it was found within the trunk of an erect *Sigillaria* is not sufficient; for we know that hollow *Sigillariæ* were often filled with foreign materials. Dr. Dawson has himself obtained from trees at the Joggins, where he found this specimen, the remains of a Lizard. In one of the stems from the volcanic ash-beds at Arran I have determined the existence of some eight or ten distinct stems belonging to several genera. The stem of the *Sigillaria* was erect; and all these contained stems were arranged parallel to the stem itself.

If the argument I have employed above is of any value, the axis described by Dr. Dawson must be foreign to the *Sigillaria* in which it occurred, seeing it contains structures which are not found in any of the numerous specimens of *Stigmaria* that have been examined. The root and stem, being homological structures, are in living plants composed of similar tissues. It is impossible to conceive of another state of things existing. But in Dr. Dawson's axis there are true medullary rays and true coniferous disk-bearing tissue, neither of which occur in *Stigmaria*. I have no doubt that Dr. Dawson's fossil is a true coniferous stem, having a large *Sternbergia*-pith like some other carboniferous *Coniferæ*. The scalariform vessels occupy the position of the "medullary sheath." Though true scalariform vessels have not been detected in the *Coniferæ*, they occur in the closely allied Gymnospermatous order *Cycadeæ*. The single series of disks on the walls of the vessels indicate an affinity between this fossil and the Abietineous Conifers; there are, however, other characters which make it impossible at present to refer this and similar fossils with certainty to any recognized group. I believe Dr. Dawson's fossil to be the same as a stem which has for some time been engaging the attention of Prof. Williamson, for which he has proposed the name *Calamopity*, and a full description of which may be early expected from him.

In conclusion, we may inquire what light the reproductive organs figured by Goldenberg throw upon this question. These consist of several small sporangia borne on the dilated bases of slightly altered leaves. The sporangia in size and form agree exactly with what I have described in *Flemingites*; but their arrangement on the supporting leaves is very different in the two genera. In *Flemingites* they are borne in a double row on the horizontal portion of the leaves which form the cone. I have recently detected similar sporangia associated with a true Lepidodendroid plant from a Carboniferous deposit from the South of Brazil. That these sporangia belonged also to the genus *Sigillaria* is very probable, independent of the direct observations of Goldenberg, from the enormous quantity of these capsules which occur in some coals, imparting to them special valuable properties.

Dr. Dawson says he has never found the detached fruits (*Trigonocarpum* and *Rhabdocarpus*) which he associates with *Sigillaria* attached to them; and we need not, therefore, consider what claims they have to be so considered.

The structure of the fruits of *Sigillaria* and allied genera may be characterized as follows:—

Triplosporites, R. Br. Cone with a single sporangium borne on each scale; the sporangia of the upper portion of the cone containing microspores, while those of the lower portion contain macrospores.

Lepidostrobus, Brongn. Cone with a single sporangium on each scale; all the sporangia filled with microspores.

Flemingites, Carr. Cone with a double series of small sporangia on each scale.

Sigillaria, Brongn. Cone with a single patch of small sporangia on the enlarged base of the scale.

It is probable, from the recent observations of Brongniart, that we as yet know the macrospores of only one genus, viz. *Triplosporites*, R. Br.; but this would correspond with the state of our knowledge regarding the similar organs in the living *Lycopodiaceæ*; for of the two principal genera of this Order, the microspores only are known in *Lycopodium*, while both kinds of spores occur in *Selaginella*.

EXPLANATION OF PLATE X.

Figs. 1–3. From a specimen of *Stigmaria* in which the whole of the cellular tissue had decayed and the spaces occupied by it had been filled with amorphous clay; thereafter the vascular cylinder itself decayed, exposing the form of the medullary axis and the meshes for the vascular bundles. Fig. 1. Longitudinal section, showing that the meshes proceeded outwards at right angles to the axis. Fig. 2. The casts of the meshes, seen from above. Fig. 3. Ditto, seen from below.

Figs. 4–7. From a specimen of *Stigmaria* in which the vascular tissue is well preserved, but all the cellular structure has been replaced by amorphous material. Fig. 4. Transverse section of the vascular cylinder. Fig. 5. Oblique perpendicular section, gradually sloping outwards from above downwards. The vascular bundle is seen as a ridge at the base of the triangular cavity. This vascular ridge produces the double structure in the cast of the cellular cavity as seen from below in fig. 3. Fig. 6. The two upper meshes of fig. 5, magnified six times, showing the ends of the vessels passing outwards, and the longitudinal section of the scalariform vessels of the cylinder. Fig. 7. Longitudinal section of a portion of the cylinder, magnified six times, parallel to the meshes, showing no indication of medullary rays.

Fig. 8. A vascular bundle and its accompanying cellular tissue from a section of the original specimen of *Lepidodendron Harcourtii*, Lindl. & Hutt. The large cells surrounding the drawing are the parenchyma of the circumference of the stem. The cellular tissue belonging to the vascular bundle is composed of small cells with very delicate walls. This tissue so readily decayed that I have never seen it in any specimen of *Stigmaria*, or in any of these stems except this *Lepidodendron*.

Discussion.

Prof. Morris insisted on the necessity of the student of fossil botany being thoroughly acquainted with modern botany also. It was from specimens discovered many years ago by Mr. Prestwich that the true nature of the *Stigmariæ* had been discovered; and he quite agreed with the author in regarding them as cryptogams, and in no way connected with gymnosperms. The abundance of cryptogamic spores in coal was hardly at present appreciated. There were some varieties of coal almost exclusively composed of such spores.

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3. *On the* British Species *of the Genera* Climacograpsus, Diplograpsus, Dicranograpsus, *and* Didymograpsus. By H. Alleyne Nicholson, D.Sc., M.B., F.G.S.

[This paper has been withdrawn by permission of the Council.]

April 14, 1869.

Captain William Price, M.P., of Tibberton Court, near Gloucester; Sir David Wedderburn, Bart., M.P. of 17 Pall Mall; A. Rogers, Esq. (Bombay Civil Service), Heath End House, Hampstead; W. E. Koch, Esq., 31 Oxford Square, Hyde Park; and the Rev. James Kernahan, M.A., Ph.D. (Rostock), F.R.S.L., F.E.S., 50 Greenwood Road, Dalston, were elected Fellows of the Society.

The following communications were read:—

1. *On the* Coal-mines *at* Kaianoma, *in the* Island *of* Yezo. By F. O. Adams, Esq., H.M. Secretary of Legation in Japan.

(Communicated by the Secretary of State for Foreign Affairs.)

[Abstract.]

The writer stated that the works at Kaianoma have made considerable progress since they were reported upon by Mr. Mitford last year*. There are four seams of coal, each about 7 feet thick and at a distance from each other of from 50 to 100 feet. Mr. Adams

* See Quart. Journ. Geol. Soc. vol. xxiv. p. 511.

mentions a tunnel, 430 feet above the sea-level, bored through the whole thickness of one of the seams for a distance of between 150 and 250 feet. A cross tunnel near the mouth of this reached coal at a distance of 50 feet. The coal is carried down to the shore by men, mules, and ponies; its price on the spot is 4 dollars per ton.

Mr. Adams also stated that, from what he had heard, there are unworked coal-seams in the neighbourhood of Otarunai, and indications of lead, copper, and even gold in various parts of the island.

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2. *On a* Peculiarity *of the* Brendon Hills Spathose-Iron-Ore veins. By M. Morgans, Esq.

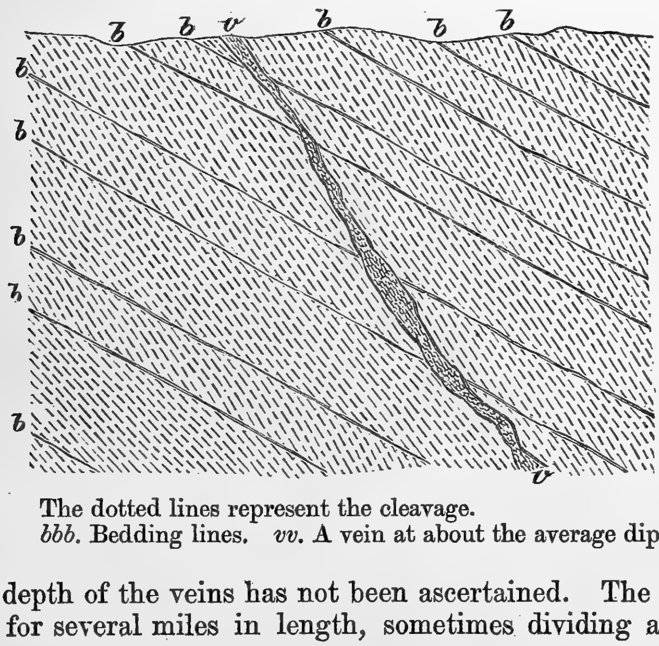
(Communicated by Warington W. Smyth, Esq., F.R.S., V.P.G.S.)

[Abridged.]

According to the author the Brendon Hills consist of a Devonian Slate, dipping about S. by E. at 30°, and N. by W. at 60° on the two sides of the axis of elevation. The cleavage-laminæ dip nearly S. by W. at 80°; and the cleavage-strike varies but little from E. by N. and W. by S., forming only a slight angle with the *main axis* of elevation.

The clay-slate of the Brendon Hills contains very fine lenticular veins of spathose iron-ore exceedingly rich in manganese, the dip and strike-lines of which are not influenced by irregularities in the strata, but for the most part follow the direction of the cleavage-planes, although, as they are often tortuous, they do not constantly coincide with them (fig. 1).

Fig. 1.—*Cross Section of a Vein.*

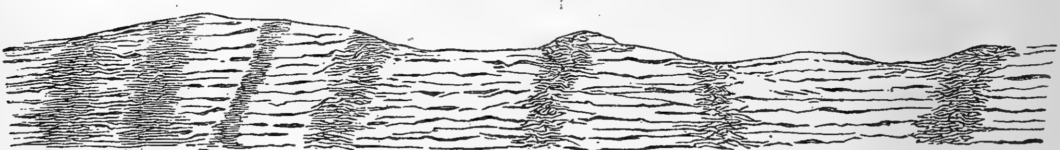


The dotted lines represent the cleavage.
bbb. Bedding lines. *vv*. A vein at about the average dip.

The depth of the veins has not been ascertained. The main ones extend for several miles in length, sometimes dividing and reuniting. The greater part of each vein is "dead" or unproductive; the productive portions or "pockets" vary from a few yards to 100 fathoms in length and from a few inches to nearly 30 feet in thickness. The pockets are sometimes very close together, sometimes more than a mile apart in the same vein; in all cases they are connected by a vein-"track," consisting chiefly of softened clay-slate and quartz with occasionally a little iron-ore (fig. 2).

The "pockets" are found not to descend parallel to the line of their dip, but to *slope endwise*, generally to the west, but in one or two cases to the east. To this phenomenon the author gives the name of "end-slant." He accounts for it in the following manner. He

Fig. 2.—*Longitudinal Section of a Vein.*



p t p p t p t p t p t p

ppp. "Pockets." *ttt.* Vein-track.

assumes that the veins have been segregated from the adjoining clay-slate, the unproductive portions occurring where the continuous strata were not sufficiently impregnated with ferruginous matter to produce a lode of ore, the "end-slant" of each productive part being "determined by the line of intersection of the sloping plane of the vein with the boundaries of the ferruginous portions at the commencement and termination of each 'pocket.'"

Discussion.

Mr. Etheridge thought that the great iron-lodes of this district lay in the great faults which traverse the country, and in which there had been considerable downthrow to the north. In most cases in the Bristol district the lodes seem to have been formed at the bottom of the sea during the New-Red-Sandstone period by infiltration of salts of iron into the faults.

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3. *On the* Salt-mines *of* St. Domingo. By F. Ruschhaupt.

(Communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.)

[Abridged.]

The author described the Cerro de Sal, or Salt-mountain of St. Domingo*, as subordinate to the main chain of mountains running in a S.E. and N.W. direction, its own direction being E.S.E. and W.N.W. The eastern part of the Cerro de Sal is very rugged and steep, rising to 550 or 600 feet; towards the W. it becomes lower, and forms a chain of irregular hills.

* See Quart. Journ. Geol. Soc. vol. xxiv. p. 335.

The rocks of which the mountain is composed are referred by the author to the "Red-Sandstone class." Below, where the chief visible salt-deposits occur, the rocks are chiefly gypsum-schists, sometimes very argillaceous, rarely calcareous. The salt is generally surrounded by an ash-like mass, consisting of gypsum and clay. The higher part of the mountain is formed of gypseous rock not forming connected layers; this is compared by the author to the gypsum of the Keuper.

The salt-bearing beds are said by the author to be thrown up into a perpendicular position, and this upheaval is described by him as occurring for miles both in the hills and on the low savanas. Numerous salt-springs occur at considerable distances around the mountain.

About eighty holes have been opened by the natives upon the ridge of the mountain in order to get the salt. On the north side an immense ledge of salt is exposed, the soil having been washed away from it. The part exposed is from 250 to 300 feet broad, and is about 200 feet from the base of the mountain.

By an examination of the whole district the author has satisfied himself that the salt-deposits extend not only through the whole of the Cerro de Sal, but also down into the plains below. The adjacent hills to the north-west also bear positive evidence of containing extensive salt-deposits. The supply of salt in the great lake Enriquillo is maintained by the filtration of water down to the beds of salt and then out into the lake. The salt obtained is generally of superior quality.

Discussion.

Sir R. I. Murchison had been at a loss to understand how such beds of salt could coexist with shells said to be of recent species in St. Domingo. The question seemed, however, to have been solved by the fact that these shells are of Miocene age. The geological survey of many of the West-Indian islands had determined that nearly all these deposits were of Miocene age. In the majority of the islands there were no rocks so old as the Cretaceous; and he therefore suspected that there must have been an error on the part of the author in regarding the beds of St. Domingo as belonging to the Trias. The salt of St. Domingo is therefore of the same age as that of Wieliczka in Poland.

Prof. Ramsay thought it was more remarkable that any salt-deposits of the New Red Sandstone should exist than that there should be so many of Miocene age. There was not much probability of great salt-deposits of more recent date, as there had hardly been sufficient time for their formation, though in the Great Salt Lake and elsewhere such deposits were now forming. The reason why such old deposits of salt had been preserved appeared to be that the salt had been hermetically sealed up in impermeable marl as soon as the part of the salt which lay near the outcrop of the beds had been dissolved away.

Mr. Etheridge was satisfied that the shells from St. Domingo which came with the salt are of Miocene age. In other West-India islands gypsum of Miocene age occurred, and pseudomorphs of salt. He recommended Mr. Sawkins's work on the Geology of the West Indies to the attention of geologists.

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4. *A* Description *of the* "Broads" *of* East Norfolk, *showing their* Origin, Position, *and* Formation *in the* Valleys *of the* Rivers Bure, Yare, *and* Waveney. By Richard B. Grantham, Esq., C.E., F.G.S.

[Abridged.]

The author described the "Broads" of East Norfolk as large lakes of fresh water situated in the valleys of certain rivers, such as the Bure, Yare, and Waveney, although never directly in their course, the distance of the Broads from the above-mentioned rivers being from one quarter of a mile to three miles. They are, however, connected with the rivers by watercourses. The Broads in the valleys of the rivers Bure, Yare, and Waveney are thirty in number, twenty-three of which are in the valley of the first-named river. The author gives the following list of them with their areas in acres:—

I. *On the River Bure and its Tributaries.*

	Acres.			Acres.
Ormesby, Rollesby, & Filby	464·9	Catfield ...	on the river Ant.	22·4
Walsham	62·1	Oliver ...		23·0
Ranworth	117·6	Barton ...		229·6
Little	13·3	Stalham...		75·6
Decoy	22·0	Dilham ...		17·6
Salhouse	22·8	Hickling & Whitesley	on the Hundred Stream	578·0
Burnt Fen	11·7	Womack .		25·5
Hoveton, Little	57·6	Chapmans		46·8
Hoveton, Great	121·5	Martham		115·5
Wroxham	92·4	Horsey ...		130·6
Bridge	12·8	Calthorpe		13·8
Belaugh	12·0			

II. *On the River Yare.*

Buckenham	20·1
Strumpshaw	17·1
Rockland	117·0
Surlingham	104·0

III. *On the River Waveney.*

Fritton	157·0
Flixton	12·8
Oulton	99·0

The aggregate area amounts to 2816 acres.

Many of the Broads are being reduced in size by the deposition of decaying vegetable matter, and the accumulation of detritus brought into them by the small streams which feed them. The bottoms of Martham, Hickling, Whitesley, and Horsey Broads are about on the level of low water at Yarmouth; the bottom of the united Ormesby, Rollesby, and Filby Broads is from 12 to 14 feet below that level. The surface of the water in the last-named Broad is about 2 or 3 feet above that of high water.

The author maintains that the "Broads," although freshwater lakes, are relics of a time when the whole of these valleys were submerged, and in fact formed great estuaries. He instances the salt-water lake called Breydon Water, which lies on the west of Yarmouth, and to which the tide still has access; this at present receives the waters of the Bure, the Yare, and the Waveney.

The author considers that the submergence of these valleys may have persisted in part until the historic period; for it is stated that in the year 1004 Sweyn took his fleet up to Norwich and burned that city; and as late as the year 1347 Yarmouth stood upon an island, being separated from the mainland by a northern channel called "Grubb's Haven," which was subsequently silted up.

Discussion.

Mr. Gwyn Jeffreys suggested a zoological as well as a geological examination of these lakes. If of marine origin, possibly some marine forms might be found still existing in them, as had been discovered to be the case in some of the lakes of Sweden.

Mr. Searles Wood, Jun., agreed that these broads were of later date than the excavation of the valleys. He cited Mr. Prestwich's account of the boring at Yarmouth, which showed a large amount of silting up of the valley.

Mr. Prestwich inquired whether the amount of silt at the bottom of these broads had been ascertained, and whether any estuarine shells had been found in the beds at the bottom.

Prof. Ramsay suggested that the broads might be relics of the old valleys of the time when the Thames and other rivers of the east of England united with the Rhine and other continental rivers to flow into the Northern Ocean.

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5. *On a peculiar Instance of* Intraglacial Erosion *near* Norwich. By Searles Wood, Jun., Esq., F.G.S., and F. W. Harmer, Esq.

(The publication of this paper is deferred.)

[Abstract.]

The authors described the general structure of the valley of the Yare, near Norwich, in which the fundamental chalk-rock is covered by the following drift-beds:—1, the Chillesford sand and clay; 2, pebbly sands and pebble-beds; 3, the equivalent of the contorted Drift of Cromer; 4, the middle glacial sand; and, 5, the Boulder-clay. The valley is hollowed out in these beds. Sewer-shafts sunk in the bottom of the valley near Norwich have shown the existence of an abrupt hole or narrow trough in the chalk, having one of its sides apparently almost perpendicular. This is filled up in part by a deposit of dark-blue clay, full of chalk débris, exactly resembling the Boulder-clay at a distance from Norwich, but quite different in character from that occurring in the vicinity (No. 5); and this is overlain in part by a bed of the middle glacial sand (No. 4), and in part by a postglacial gravel. The authors believed that this peculiar hole or trough was excavated by glacial action after the deposition of the bed No. 3, and that it belongs to the earliest part of the

middle glacial period. At Somerleyton Brick-kiln, near Lowestoft, a perfectly similar bed occurs between the drift and sand (Nos. 3 and 4).

Discussion.

The President inquired whether the perpendicular wall of chalk shown in the section could be due to the action of a glacier, as supposed by the author.

Mr. Prestwich suggested that the depressions formed in the chalk in other districts by chemical action might possibly throw some light on the case.

Mr. Evans thought it possible there might have been a valley originating in a large fissure, and partly filled up with reconstructed glacial deposits.

Prof. Ramsay was inclined to accept the solution offered by Mr. Prestwich, and could not see any traces of the action of a glacier.

Mr. Etheridge thought the phenomena might be accounted for by a fault.

Mr. Hughes pointed out that the clay-bed was totally different from any of the beds supposed to have been let down.

Mr. Searles Wood, Jun., in reply, relied on the difference in character of this bed to prove that the case was not the result either of a fault or of beds being let down into a pothole. He had made a mistake in using the word "glacier" instead of "iceberg."

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6. *On the* Lignite Mines *of* Podernuovo, *near* Volterra. By E. J. Beor, Esq., F.G.S.

[Abstract.]

The author stated that the deposit of Lignite at Podernuovo, near Volterra, is of lacustrine origin, and consists of two parallel strata of compact coal about $2\frac{1}{2}$ metres (=8 feet 4 in.) in thickness, separated by a thin stratum of marl, with marsh-shells. The lower coal-bed lies on a bed of marl with marsh-shells, and the upper bed is covered by a marine formation belonging to the Upper Miocene. The lignite comes to the surface near the Alberese, where it is thrown up in a large mass and extends for a considerable distance. In the Monterufoli valley, where the lignite is worked, its inclination is found to be about 42° at a depth of 40 metres, where it is intersected by an adit-level driven from the surface of the hill for the removal of the lignite. Two galleries have been driven at right angles to this to a distance of 120 metres right and left through the lignite. Some shifts occur bringing the upper bed down nearly to the level of the lower one; the inclination of the beds diminishes gradually; and the intervening stratum of marl decreases in thickness, and probably at last thins out altogether. The coal in the upper bed is better than that in the lower one. The author remarked that this lignite deposit differs from those of the neighbouring valleys (such as the Val di Bruno, Val di Pecora, Val di Cornia, and Val di Cecina), in being purely of marsh origin, while they are estuarine.

April 28, 1869.

Daniel Jones, Esq., of Donington, near Wolverhampton, and Thomas Heathcote Gerald Wyndham, Esq., Fellow of Merton College, Oxford, of Sock Dennis, Ilchester, were elected Fellows of the Society.

The following communications were read:—

1. *On the* Geology *and* Mineralogy *of the* County of Hastings, Canada West. By T. C. Wallbridge.

(Communicated by Dr. Percy, F.R.S.)

Contents.

I. Introduction.

Within the last two or three years, considerable excitement has been aroused by the discovery of gold in several localities in the North Riding of the County of Hastings. Long previously, attention had been directed to the occurrence of valuable deposits of iron-ore distributed through the northern townships of the county; but although attempts have been made from time to time to explore a few of these deposits, no systematic or extensive workings have yet been undertaken, and at the present time these iron-ores remain almost entirely undeveloped. Looking, however, to the extensive mineral resources of North Hastings, and to its favourable geographical position, it can hardly be doubted that many of the townships are destined to become important mining-districts; and the object of the present communication is to lay before the Society an account of the chief mineral deposits, so far at least as they admit of description in their present undeveloped state.

Before describing these minerals, however, it seems desirable, for the better understanding of their mode of occurrence, to give a general sketch of the geological features of the country. Much information on this subject may be found scattered through the pages of the admirable Reports issued by the Geological Survey of Canada; but the following description is mainly the result of personal observation and local knowledge derived from a long residence in that part of Canada.

The County of Hastings is situated on the north shore of the Bay of Quinté in Upper Canada. It was formerly divided into the North and South Ridings, all the minerals of economic value being confined to the former division. The geological formations exposed within the limits of the county comprise, in descending order, the Drift, Lower Silurian strata, and certain Laurentian rocks.

II. Geology of Hastings.

1. *Recent Deposits.* — Before describing the several geological formations of the county, a few superficial deposits of local occurrence and of recent origin merit a brief notice, partly from their geological interest and partly from their economic value. Thick beds of a white *shell-marl,* charged with *Cyclas, Planorbis,* and other freshwater shells, are scattered here and there over the surface of the county. In many of the small shallow lakes this marl is still in course of deposition. The waters of such lakes often contain carbonate of lime to such an extent that any object exposed to their action is readily coated with a calcareous incrustation. From July to November many of these lakes are more or less completely dried up, and the marly deposits covering the bottoms are then exposed. "Lime Lake," a considerable expanse of shallow water in the south-east angle of Hungerford, derives its name from the calcareous deposit which it thus throws down. Marl-beds of a similar lacustrine origin often attain a thickness of several feet, and sustain a rank vegetation—cedar-swamps (*arbor vitæ*), for example, commonly standing upon such deposits. The occurrence of this freshwater marl is well exposed on the drift forming the higher banks on the west side of the river Moira above Belleville. No attention has hitherto been directed to the utilization of this shell-marl; but it obviously possesses considerable value to the agriculturist as a fertilizer, and may perhaps be useful to the metallurgist as a flux, as well as for making the cupels or hearths used in refining auriferous and argentiferous lead.

In a country which possesses no workable quantity of coal, more than ordinary interest attaches to the occurrence of *peat.* Deposits of this fuel, often of considerable thickness, are extensively distributed through the mineral regions of Canada, and must eventually play an important part in the development of its mineral resources. Nearly all the smaller lakes scattered over the Laurentian area contain, either at their outlets or in sheltered coves along their margins, considerable accumulations of vegetable remains, which have partly grown in their present position and partly been drifted thither by winds or by the current of the river flowing through the lake. Year after year these stagnant accumulations are increased, and eventually become converted into a peaty substance sufficiently compact to admit of a rich vegetable growth upon the surface.

In connexion with the occurrence of peat, attention may be directed to the deposits of *bog iron-ore,* which are widely distributed over the surface of the country, and in certain localities appear to be still in course of formation. Although bog iron-ore usually contains phosphorus, it yields an iron which from its easy fusibility is highly valued for castings. Bog-ore has been employed with most satisfactory results at the St. Maurice and Radnor forges, both in Canada East. The bog-ore of Hastings is especially abundant in the township of Marmora, but has not hitherto been brought into use.

2. *Post-Tertiary.*—Neglecting the recent formations, which are of local occurrence only, the surface of the county is for the most part covered by an extensive accumulation of sand, gravel, and clay, with boulders of northern rocks, forming a portion of that general covering of drift which overlies the greater portion of the province, and extends southwards into the United States. The upper part of these deposits consists of a series of sands, gravels, and clays, more or less distinctly stratified, and usually resting upon a tenacious unstratified Boulder-clay. The boulders are derived partly from the syenitic, gneissoid, schistose, and limestone rocks of the northern Laurentian area, and partly from the wreck of the thick-bedded limestone, which will be subsequently mentioned as forming a part of the Trenton group, and which, previously to its denudation, overspread a great portion of the Laurentian rocks of the northern townships of Hastings. Many of the blocks have a volume of several cubic yards each, and are often broken up for road-metal. A single boulder or ice-borne mass of Laurentian rock, at the Shannonville Station on the Grand Trunk Railway, covers a superficial area of about 5 acres, and has a thickness of 100 feet. Isolated boulders are not unfrequently found on the tops of hills, where they have probably been left by the denudation of the deposit in which they were originally imbedded.

The accumulations of drift are sometimes heaped up in isolated hillocks, or in ranges of hills, and sometimes spread out over the valleys. A cutting in the Court House Hill, in Belleville, exposes a good section of the drift. Upon a base of Trenton limestone, the surface of which is highly polished and grooved, there is an accumulation of deposits attaining an aggregate thickness of about 60 feet, and consisting below of a tenacious Boulder-clay, overlain by a thick bed of blue clay and a series of finely stratified sands and gravels. In the blue clay there frequently occurs the cast of a peculiar organism, supposed to be a plant, which presents either a ramified or a lenticular form and attains a size of from 2 to 3 inches in diameter, and from 1 to $1\frac{1}{2}$ inch in thickness.

A succession of deposits, similar to that exposed at the Court House Hill, may be seen in the Oak Ridge—a range of drift-hills running across the country from East to West, having a width of from 3 to 6 miles, and varying in height from 100 to 500 feet.

On removing the superficial accumulations, the subjacent rock, whether gneiss, schist, or limestone, usually exhibits distinct traces of having been subjected to glaciation. Many of the rocks are highly polished, whilst others are distinctly striated and grooved, the general directions of the markings being from N. E. by N. to S. W. by S. Some remarkably distinct ice-scratches were exhibited in the town of Belleville in the autumn of 1864, when a cutting was made in Pinnacle Street. The section exposed about 30 feet of "hard pan," or gravel, with boulders of calcareous and syenitic rocks, resting on the Trenton limestone. The surface of this limestone, when freshly-exposed, was most distinctly polished and striated, the general bearing of the marks being N. 35° E. and

S. 35° W. Other less strongly-marked striæ varied slightly from this common direction.

On the road from Belleville to Shannonville, on the first concession of Thurlow, between Lots 24 and 25, I have observed the direction of ice-marks on the outcropping Trenton limestone to be E. 85° N. and W. 85° S.

A careful study of the deposits here grouped together as "drift" would apparently lead to the conclusion that their formation is referable to the action of two distinct agencies—the one a force similar to that of land-ice pushing before it an accumulation of northern rocks, whilst it rounded, polished and grooved the country over which it swept, and the other an action similar to that of icebergs scattering their freight of gravel and angular fragments of rock over the bed of the sea. The eastern half of the township of Hungerford, and the northern ranges of Huntingdon and Rawdon, are thus covered with scattered angular blocks of limestone removed from the Laurentian area, some of the blocks exhibiting distinct glacial markings. Between the period of glacier ice and that of floating ice the stratified sands and clays appear to have been deposited in comparatively tranquil water.

3. *Lower Silurian.*—In the South Riding of Hastings is an extensive development of that division of the Lower Silurian formation distinguished as the *Trenton group*, including under that name not only the Trenton Limestone proper, but also the Bird's-eye and Black-River Limestones. The upper portion of the Trenton group consists of a series of thin-bedded shaly limestones, occasionally interstratified with beds of calcareous clay, and highly charged with the characteristic fossils of the Trenton Limestone. These rocks generally strike in an east and west direction, and are for the most part horizontally bedded, or have only a gentle dip to the south-west, with occasional evidence of a slight upheaval. In the shallow valleys of denudation which in many places intersect the county, sections of these limestones are occasionally exposed; but as a rule they are almost completely obscured by a covering of drift.

The thin-bedded fossiliferous Trenton Limestones rest conformably upon a thick-bedded limestone almost destitute of fossils, only three species having hitherto been detected. Probably this thick-bedded limestone represents the Bird's-eye and Black-River series. Sections are exposed along an escarpment, varying from 50 to 100 feet in height, which forms the junction of the Trenton beds with the underlying Laurentian rocks. This escarpment gives direction to the drainage from the Laurentian watershed of this part of Canada.

The total thickness of the Trenton Limestone at Belleville may be estimated at about 800 feet. A boring to the depth of 600 feet was sunk about 15 miles S. W. of Belleville, in the County of Prince Edward, without reaching the base of the series; and another boring, 7 miles north of Belleville, 500 feet deep, was attended with a similar result.

Whilst the Trenton group of rocks is almost confined to the southern part of the county, it is notable that two large outliers of the thick-bedded limestone are found in the Laurentian area of Madoc, at a considerable distance from the main mass. In a lecture delivered at Madoc in 1866, I called attention to these outlying patches. One of them occurs about a mile south of the Richardson gold-mine, and the other at a distance of about 2 miles S.E. of the former mass. The N. and N.E. sides of these outliers present prominent escarpments, whilst the other sides have a gentle slope. Other smaller outliers of limestone are scattered over the Laurentian area; and all are of interest as attesting the extensive denudation which the country has suffered.

At the base of the Trenton group there is found in certain localities of the North Riding a thin band of grey limestone, having so extremely fine a texture as to render it well adapted for use as a lithographic stone.

In the township of Hungerford the Trenton limestone is occasionally underlain by an unfossiliferous calcareous sandstone, supposed to represent the *Calciferous Sand-rock* and *Potsdam Sandstone,* which form the base of the Lower Silurian formation.

4. *Laurentian.*—The Lower Silurian beds usually rest unconformably upon a very irregular surface formed by the denuded edges of a large group of highly inclined strata of metamorphic rocks, which have been referred provisionally to the Lower Laurentian formation. These rocks are exposed over a large portion of the North Riding, and consist of a very diversified series of micaceous, hornblendic, and chloritic schists, interstratified with beds of granular and crystalline limestone, and penetrated by bosses of syenitic and gneissoid rocks. Bands of conglomerate occur locally, and consist of quartzose, felspathic, and calcareous pebbles, imbedded in a matrix of micaceous schist or of dolomitic limestone. Most of the stratified Laurentian rocks exhibit evidence of having been highly disturbed, the dip being extremely irregular, and often at a very high angle. An apparent inversion of the rocks may be seen in the adjoining townships of Tudor and Madoc. Traces of an organic structure referred to *Eozoon Canadense* have been detected by the Geological Survey of Canada in the limestones of Madoc and Tudor; but it is supposed that these rocks may be placed on a higher horizon than the Eozoonal limestones of Grenville. Indeed Sir William Logan admits that the stratigraphical position of the crystalline rocks of Hastings is by no means satisfactorily determined; but he adds that "it would be premature to remove them from the horizon in which they have been provisionally placed."

In addition to the extensive development of these so-called Laurentian rocks in the northern townships, domes of similar syenitic and gneissoid rocks are exposed in several parts of the Trenton-Limestone area to the south, where the overlying limestone has been planed down or removed by denudation.

It has been suggested that certain labradorite rocks forming a range in the township of Tudor, known locally as the "Hole in the Wall," may be regarded as outlying masses of the Labrador or Upper Laurentian series.

III. On the Occurrence of Gold.

All the rocks in which gold has recently been discovered in the County of Hastings are comprised within the Laurentian area, known as the Quinté Gold-mining District. The first discovery of the precious metal was made in 1866, during an unsuccessful search for copper ores. Superficial indications of the occurrence of copper in the township of Madoc had previously led to the prosecution of irregular workings in several localities; but none of the explorations had been characterized by any measure of success. At length, however, a specimen was obtained from one of these so-called mines which, although at first mistaken for native copper, was soon found to be native gold. Stimulated by this discovery, further search was prosecuted; and at the locality which subsequently became famous as the "Richardson Mine," a considerable quantity of free gold was discovered in two pockets, or irregular cavities, at a depth of about 15 feet below the surface. Considerable interest attaches to this mine, not only on account of the large amount of gold which it yielded within a very short space of time, but more especially on account of the peculiar conditions of association under which the metal occurred.

The Richardson Gold Mine is situated on the eighteenth lot of the fifth concession in the township of Madoc. The surrounding rock consists of an epidotic and chloritic gneiss, enclosing a bed of steatitic schist, and associated in certain places with a ferruginous dolomite. A peculiar character is given to this dolomite by the local occurrence of a black carbonaceous substance which, in external characters, bears considerable resemblance to a lignite, but which is regarded by Dr. Sterry Hunt as probably an altered form of bitumen. It occurs imbedded in the dolomite, in small irregular fragments, which break with a conchoidal fracture, and present a pitch-black colour and a resinous lustre. Heated in the open air, it readily ignites, burning with little or no flame, and leaving a residue which, in a specimen examined by Dr. Hunt, consisted of "carbonate of lime, with some siliceous and ferruginous matter, including a quantity of gold."

This friable carbonaceous substance, in association with ochrey oxide of iron, incrusted the walls of the gold-bearing pockets of the Richardson Mine, and formed the matrix through which the metal was chiefly disseminated. It would appear that these pockets are merely expansions of a fissure running along the plane of bedding between the highly inclined rocks of the surrounding country. The contents of these cavities have evidently been derived from the decomposition of the surrounding dolomite; for that rock, as seen by the specimens exhibited, contains the disseminated carbonaceous matter, together with free gold, whilst it appears to be sufficiently ferruginous to yield the oxide of iron on decomposition. Whether the carbonaceous substance has, by its reducing action, played any part in the genesis of the gold is a chemical question on which the writer is not prepared to enter; but their intimate association in this mine is at least highly suggestive. Moreover the presence of the carbonaceous matter, not in cavities in the dolomite, but imbedded in the rock itself, is a point of considerable significance to the palæontologist, as indicating the existence of organic remains in rocks which have been referred to so old a formation as the Lower Laurentian.

The gold yielded by the pockets of the Richardson Mine usually occurred in a finely divided state, or in the form of small scales and dendritic fragments, but never exhibited distinct crystalline forms. It presented a reddish-yellow colour, and was remarkably pure. A specimen assayed in Toronto was between 22 and 23 carats fine, the native metal being thus quite as pure as the standard gold of this country. The auriferous material extracted from the pockets (consisting of the carbonaceous and ochreous substances) yielded from £3 to £4 worth of gold to the pound. How much of this gold-stuff the mine actually produced it is extremely difficult to estimate; for whilst the workings were in the hands of Mr. Richardson, considerable quantities were surreptitiously carried off by parties who gained access to the mine, and were distributed to so large an extent that, even at the present time (now more than two years after the discovery), specimens may readily be purchased in the neighbourhood. It is said that upwards of 60 lbs. of the auriferous material were sent to the United States by the first purchasers of the mine, and subsequently three barrels of the same material were forwarded to New York. It is commonly supposed that the total value of the gold yielded by the pockets of the Richardson Mine was not less than £10,000.

When, however, the two deposits were exhausted the supply ceased, and attention was then directed to working the surrounding "country," where the gold exists either in so finely divided a state as to escape detection by the eye, or in combination with iron-pyrites and other metallic sulphides.

It has been said that the metal was confined exclusively to the fissure, and that it could not have been derived from the adjacent rocks, as these, if not entirely destitute of gold, are impregnated with it only to a very limited extent in the immediate neighbourhood of the crevice. Such a statement however, is, entirely contradicted by a chemical examination of rocks broken at a considerable distance from the pockets. Several assays have been made by Professor T. Bell, of Albert College, who has kindly furnished me with the results. Two specimens of dolomite from the Richardson Mine yielded respectively 9 oz. 11 dwts. 16 grs., and 4 oz. 5 dwts. 17 grs. of gold per ton of 2000 lbs.; whilst the metallic sulphides, chiefly iron-pyrites, washed from these two specimens contained as much as 88 oz. of gold to the ton. The average value of the gold-stuff at present crushed at the mine is only about £1 per ton; but even this is found to be more than sufficient to cover the working-expenses. It should be noted, however, that all the gold thus obtained is extracted by amalgamation; and as the rock contains a large percentage of auriferous sulphides, it is probable that larger returns would be yielded by a metallurgical treatment better adapted to the character of the ore.

In the same township as the Richardson Mine, gold-ores have recently been worked at several localities. The Madoc Gold-Mining Company's shaft on lot seventeen in the seventh concession of Madoc was sunk on a quartz lode, coursing through gneiss N. 15° W., and dipping about 60° W. Very little free gold was visible; but the iron-pyrites disseminated through the quartz was apparently auriferous. Samples of vein-stuff from near the surface yielded about £12 10*s*. of gold to the ton, and at a depth of between 30 and 40 feet Professor Chapman found the quartz to contain 3 dwts. 12 grs. of gold, and 1 oz. 11 dwts. 12 grs. of silver per ton; but at a depth of about 60 feet the vein became entirely barren of gold.

At the Empire Mine, also situated in the township of Madoc, both gold and silver have been obtained from a vein-stone containing arsenio-antimonial grey copper-ore, together with mispickel, iron-pyrites, and bitter-spar. According to Professor Bell's assay, the grey copper-ore contained 8 oz. 4 dwts. of gold, and 331 oz. of silver to the ton of 2000 lbs., the value of which would be £95; and this result was confirmed by Dr. Sterry Hunt, who found that the dressed ore, when holding one-fourth its weight of vein-stone, yielded 9·7 oz. of gold, and 120·7 oz. of silver to the ton of 2000 lbs.

In the adjacent township of Marmora auriferous quartz has been worked at the Feigle Mine, opened on lot sixteen in the eleventh concession. The gold is here associated, as in so many other gold-bearing localities, with a vitreous quartz more or less stained with hydrous peroxide of iron. Mr. Bell has found that one sample of this quartz yielded, by amalgamation, 3 oz. 13 dwts. 8 grs. per ton, whilst another portion contained 7 oz. 15 dwts. 12½ grs. per ton. [A specimen exhibited from the Feigle Mine showed the free gold imbedded in a large prismatic crystal of liver-coloured Eisenkiesel, or quartz charged with hydrous peroxide of iron.]

At the Barry Mine, in the township of Elzevir, a dark crystalline limestone is crushed for gold. The mean of four assays of ore, discovered in this township by Mr. Smallfield, yielded gold to the value of nearly £8 per ton of 2000 lbs.

From the township of Hungerford, quartz containing much iron-pyrites has been found to contain both gold and silver, probably in association with metallic sulphides.

Nothing would be easier than to considerably extend this list of gold-bearing localities. Indeed it appears that the metal is distributed, in greater or less quantity, through most of the schistose rocks of the gold-mining region; for I have invariably found that these rocks yield, on assay, a notable amount of metallic sulphides more or less auriferous. Probably the most advantageous mode of treating these sulphides would be to smelt them to a rich regulus, which might be then exported to England for extraction of the gold.

Note.—The following assays of gold-bearing rocks, from the Quinté gold-mining district, by Professor Chapman, of University

College, Toronto, are of value, as showing the average quality of the ores found in this locality :—

	oz.	dwts.	grs.	
No. 1. From Madoc.				
Gold		= 3	12	per ton.
Silver		= 7	14	,,
No. 2. Ditto.				
Gold		= 7	20	,,
Silver		=18	7	,,
No. 3. Ditto.				
Gold		= 5	21	,,
Silver		=14	9	,,
No. 4. Ditto.				
Gold		=19	12	,,
Silver		= 3	4	,,
No. 5. From Madoc.				
Gold	=1	17	2	per ton.
Silver	=0	4	14	,,
No. 6. Ditto.				
Gold	=1	11	17	,,
Silver	=0	6	12	,,
No. 7. Ditto.				
Gold	=1	1	9	,,
Silver	=0	3	8	,,
No. 8. From Marmora.				
Gold	=1	19	5	,,
Silver	=0	5	5	,,

IV. On the Occurrence of Iron-ores.

It has long been known that extensive deposits of valuable iron-ores occur in the Laurentian rocks of the North Riding of Hastings. These ores rarely, if ever, occur in true veins, but are usually found in bedded masses, more or less distinctly interstratified with the adjacent rocks, and in many cases appearing at the junction of the gneiss with crystalline limestone. The ore-deposits traverse the townships of Madoc, Marmora, and Belmont in a general east and west direction, thus following to some extent the common trend of the strata. The iron is found sometimes in the form of magnetic ore, and sometimes in that of hæmatite.

As many of these beds of magnetic iron-ore have been ably described in the Reports of the Geological Survey of Canada, it is needless to give any detailed notice of them in the present paper. Such is the famous "big ore bed" of Crow Lake, situated on the eighth lot of the first concession of Belmont. This is the ore which was formerly smelted at the Marmora Iron Works. Above the surface of the ground, the bed exhibits a width of about 500 feet; but recent excavations at the base show that it attains a still greater development below.

The "Seymour ore bed," on the eleventh lot of the fifth range of Madoc, has also been described. This was at one time worked to a limited extent to supply the Seymour furnace at Madoc.

As magnetic iron-ore is very widely distributed through the county, it would be tedious to note its many places of occurrence; but I may perhaps call attention to a new locality in Madoc, on the nineteenth lot of the first concession, which yields a fine magnetic ore [of which samples were exhibited]. A large deposit of magnetic iron-ore, also hitherto undescribed, is found on lot nine of the sixth range of Madoc.

Before dismissing the subject of magnetic iron-ores, it may be mentioned that the deposits of this mineral attain so extensive a development as to form, in many cases, remarkable physical features of the country. Indeed the supply of ore which might be obtained by working these deposits would be practically inexhaustible. Smelted with wood-charcoal, or with peat, which must necessarily form the fuel employed, and which may be obtained to an almost unlimited extent from the noble forests and extensive peat-beds which still cover a large portion of the country, these ores would yield an iron admirably adapted to the manufacture of steel, and probably equal in quality to the celebrated Swedish charcoal-iron which has hitherto been so largely imported into this country.

In addition to the well-known magnetic ores, the Laurentian rocks of Hastings are rich in deposits of Hæmatite or red oxide of iron. In the discovery and development of these Hæmatites I have long felt much interest. The existence of the "Kane ore bed" was pointed out by me several years back, and the bed has already been described by the Geological Survey. It is situated on lot twelve of range five in the township of Madoc, and has a superficial development extending over several acres. Since the last notice published by the Survey, I have caused an excavation to be made in the field where the ore was originally discovered, and after cutting for a distance of 40 feet failed to reach the wall rock. The ore is a fine-grained Hæmatite, converted at the surface into a soft red ore. As traces of ancient workings have been found in this deposit, it is probable that the Indians formerly visited the locality for the sake of obtaining the red ochreous substance for use as war-paint. In an excavation, at a considerable depth, I have obtained bone needles and other objects of human workmanship [which were exhibited]; whilst several shells and stag-antlers that were also found in this excavation have been transmitted to Dr. Dawson, of Montreal.

The Hæmatite from the Kane ore bed has been smelted at the Radnor forges in Lower Canada, and has yielded a pig-iron of excellent quality. It has also been treated at the Atlas Works in Glasgow by the Bessemer process with very encouraging results. According to an assay made in the Metallurgical Laboratory of the Royal School of Mines, the ore contains 51·46 per cent. of iron.

In the third lot of the fourteenth range of Hungerford, there occurs a bed of Hæmatite, to which attention has not hitherto been directed. The ore is a hard fine-grained Hæmatite, breaking with a steel-grey fracture and high metallic lustre. In its present undeveloped state, it is difficult to estimate the extent of the deposit, but it is undoubtedly considerable. An assay made in the Metallurgical Laboratory of the Royal School of Mines shows that this ore contains 65·91 per cent. of iron.

Pyrrhotine, or magnetic pyrites, although not to be regarded strictly as an iron-ore, may be most conveniently noticed in this place. An extensive deposit of this iron-bearing mineral crops out on the face of a hill on the nineteenth lot of the first range in Madoc. As this mineral not unfrequently contains cobalt and nickel, it was considered desirable to examine the Canadian pyrites for these metals; but no traces of either were detected.

V. On the other Minerals of Hastings.

Whilst the gold and iron-ores form the chief mineral wealth of Hastings, the county is by no means destitute of other minerals, many of which possess considerable value in an economic point of view. The most important of these is *Galena*, extensive deposits of which may be traced for a considerable distance through the townships of Tudor and Lake. It is notable that the lead-ores thus enjoy a geographical distribution entirely distinct from that of the iron-ores. The Galena usually occurs in a gangue of calcareous spar, and forms veins or lodes coursing through the Laurentian Limestone or calcareous schists. *Copper-ores* have been found, as previously stated, but never in sufficient quantity to render their working remunerative. A small and unimportant deposit of *antimonite*, or sulphide of antimony, has been found in the township of Sheffield. *Plumbago*, of greater or less purity, is occasionally met with in the Laurentian limestones of the county, but has not hitherto been worked.

Finally, attention may be directed to two other minerals, which, although of no economic value, are of mineralogical interest as species that have not hitherto been described from this county. One of these is *Rutile*, or *oxide of titanium*, which I have found penetrating the quartz of Hog Lake in the form of stout prismatic crystals, striated longitudinally, and presenting a hair-brown colour and a strong lustre. The other mineral is *Schorl*, or black tourmaline, which occurs on lot fifteen of range four in Madoc, as a reticulated mass of slender prismatic crystals imbedded in quartz.

Discussion.

Prof. Ramsay inquired as to the proof of the existence of so large a boulder as one of five acres in extent. Under ordinary circumstances large boulders fell from higher rocks on to the surface of glaciers beneath, and were by them transported to the places where now found; but the fall of such a mass seemed almost incredible. He suggested that possibly it might be a boss of the Lower Laurentian beds standing out through Silurian strata.

Mr. David Forbes stated that the results of his own examination of some of the specimens from the gold-mines of this district did not quite tally with those recorded in the paper, especially those of the rocks in the neighbourhood of the veins. He considered that the gold in Canada was confined to the veins.

Mr. Prestwich cited the discovery of a boulder between Grantham and Peterborough, which was at least 400 feet in length, and consisted of a mass of Great Oolite.

Mr. Searles Wood mentioned a boulder of marl in the coast-section near Cromer upwards of 300 yards in length, and 60 feet in height.

Mr. Wallbridge, in reply, stated that the rock must have come at the least twenty miles from its original home. The surface of the Trenton limestone rock in the neighbourhood was striated in the direction of the boulder. There was no evidence of intrusion. The mass was traversed in two or three places by crevices.

2. *On the* Distribution *of* Flint Implements *in the* Drift, *with reference to some recent* Discoveries *in* Norfolk *and* Suffolk. By J. W. Flower, Esq., F.G.S.

(The publication of this paper is unavoidably postponed.)

[Abstract.]

The author noticed some recently discovered localities in the valley of the Little Ouse which have yielded Flint Implements, viz. at Broomhill, about 350 feet from, and 5 or 6 feet above the level of the river; at Gravel Hill, about 1 mile from, and 60 feet above the river; at Shrub Hill, about 1 mile from, and only a foot or two above the river; and at Lakenheath, nearly 3 miles from the river, and 60 feet above it. In the first three of these localities the worked flints are in coarse gravel, resting immediately on the Cretaceous beds (chalk in the first and second, gault in the third), and overlain by regular deposits of gravel and sand. The implements resemble those of St. Acheul, Thetford, and Salisbury, but present some peculiarities, from which the author inferred that each place might have had its own workmen, and that the different forms were intended to answer different purposes. At Brandon some implements formed of quartzite had been found in a bed consisting of rounded quartzite pebbles mixed with about one-fourth of flints. Flint implements occurred beneath this bed.

The author described the geographical characters of the district and the peculiarities in the distribution of the flint implements, which he regarded as in accordance with the phenomena presented by the valley of the Somme; and he argued, from the presence of rocks of foreign origin and other considerations, that the implement-bearing gravels were not transported to their present situation by the agency of the rivers in whose valleys they occur, but that the implements were made upon the spot, exposed upon the surface with the gravels in which they are found, and from which they were made, and finally covered up by the gravels and sandy beds which now overlie them.

Discussion.

Mr. Prestwich dissented from the author as to many of his conclusions. There were in the district drained by the river Ouse beds of gravel belonging to the Boulder-clay series, from which the quartzite pebbles described might have been derived. The author had not taken into proper account the formation of the valleys by erosion, and it was a mistake to suppose that others had not also attributed the formation of the implements to the close proximity of the spots in which they are found. The implements were not limited to the lower part of the gravel, though principally occurring there, but occurred even above the seams of river-shells. He inquired whether the gravel between the Little Ouse and the Wissey might not belong to the Boulder-clay series.

Prof. Ramsay agreed with the author that flint implements might be found in other localities than those in the neighbourhood of rivers. He protested against referring the gravels to the rivers as they at present exist. The ancient rivers had no doubt run at far higher levels than at present. Even the watersheds afford no gauge of the ancient bounds of the rivers.

Mr. Evans stated his belief that the gravels on the plateau between the Little Ouse and the Wissey belonged to the Glacial series. He could not agree with the author in limiting the occurrence of the implements to the base of the beds, in ignoring the eroding power of rivers, or in regarding the deposits at Lakenheath and Vaudricourt as remote from all possible river-action. He maintained that the whole of the phenomena were in accordance with the excavation of the valley, since the highest beds with implements had been deposited near Brandon, and pointed out that a large part of the great plain of the Fens had probably been formed principally by tidal action, since the deposit of the gravel-beds at Shrub Hill.

Mr. Searles Wood regarded the valleys of the district under consideration as not formed by river-action, but by tidal action during emergence of the land. He regarded the higher gravels mentioned as not of river origin, and dissented from the hypothesis of the rivers of the south of England having formerly run at very high levels.

Mr. Flower, in reply, could not accept the belief that the process of the manufacture of these implements could have been carried on during the very lengthened period supposed by Mr. Evans, as, if so, other traces of the men who formed them would have come to light. He thought the French theory of diluvial action was more in accordance with the phenomena than that of fluviatile transport.

May 12, 1869.

Francis Henry Brown, Esq., of Bishwell, near Swansea; Samuel Jenkins, Esq., 13 Clement's Inn Passage; Lieut. Walter Haweis James, R.E., Brompton Barracks, Chatham; Charles Lambert, Esq., 3 Queen Street Place; Gordon Broome, Esq., Royal School of Mines, and Thomas William Gardner, Assoc. Inst. C.E., 10 St. Augustine's Square, Camden Road, N.W., were elected Fellows of the Society.

The following communications were read:—

1. *On some of the* Results *arising from the* Bedding, Joints, *and* Spheroidal Structure *of the* Granite *on the* Eastern Side *of* Dartmoor, Devonshire*. By G. Wareing Ormerod, Esq., M.A., F.G.S.

The following pages will be confined to observations on some of the effects which bedding, perpendicular joints, and spheroidal structure have produced in the physical features of Dartmoor. In the report on the geology of Cornwall, Devon, and West Somerset, Sir Henry de la Beche states (page 157) "that the granite of Dartmoor

* The district described in this paper is included in the Map published in the Quarterly Journal of the Geological Society, vol. xxiii. p. 418.

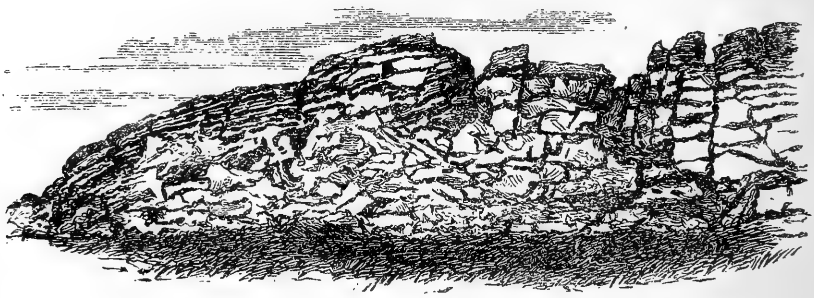
is, as a whole, a coarse-grained mixture of quartz, felspar, and mica, the latter sometimes white, at others black, the two micas occasionally occurring in the same mass. It is frequently porphyritic, from the presence of large crystals of felspar, and here and there schorlaceous; but the latter character is chiefly confined to the outskirts, where the Dartmoor granite adjoins the slates." This description is very applicable to the southern part of the district, which will now be noticed, where the granite is said greatly to resemble that of Auvergne; but to the north of the river Teign the rock is more compact and crystalline.

The apparent stratiform appearance and rapid changes of character in the beds of granite are so well known to most geologists, that it is not needful to enter upon that point at length. Mr. D. Mackintosh, in his paper "On Oblique Lamination in Granite" (Q. J. G. S. vol. xxiv. p. 279), mentions instances of the linear structure of that rock on Dartmoor, and the occurrence of striking variations in its character in overlying parallel beds. De la Beche's report states that "a very general structure prevails throughout the Cornish granites, and is more particularly observable in the large masses. This structure consists in a division of the granite into portions resembling beds, which form tabular masses when they are extensive, the edges bending beneath the adjoining schistose rocks" (page 163). I have observed that the beds also occasionally bend or dip on Dartmoor. Thus, on the north-east side of the Moor, at Scarrey Tor and Higher Belstone Tor, on Belstone Ridge, the beds of granite dip towards the Carboniferous rocks which closely adjoin them on the north-west. The last-named Tor is cut off abruptly at the south-eastern end, and the side of the hill is for a considerable distance covered with angular fragments. Possibly the granite originally dipped also to the south-east, and the beds broken up by the joints have rolled down to the river Taw. Similar curvature has been noticed in places remote from the schistose rocks; thus, on Teigncombe Common, near Chagford, more than two miles distant from the carbonaceous rocks, the granite at Kestor dips in a northerly, and at Middleton in a southerly direction—causing probably the contour of the hill, and the valleys of the north and south Teign. At Blackingstone, near Moreton Hampstead, the beds curve down on the north side, probably causing the valley that lies between that rock and the White Rock, where the beds lie nearly horizontally. At Houndtor (about halfway between Chagford and Ashburton) the beds at the west end are nearly horizontal; at the east end they curve downwards, and probably cause the valley between that and Leign Tor. These are the most obvious examples of "dip" in the granite that I have noticed in the district to which this paper relates; in all these cases the dip is very perceptible, and quite distinct from oblique lamination.

The same Report states (page 165) that "it is the intersection of the more or less perpendicular joints or divisional planes with the stratiform structure in the Cornish and Devon granite which gives it the appearance of being composed of a multitude of rectangular blocks;" and the observations of Professor Sedgwick and Mr. Enys are there quoted (page 171) to show that the general direction of the lines of joint in Devon and Cornwall is from N.N.W. to S.S.E., and that on the northern part of Dartmoor the granite is also cleaved in lines at right angles to it, or nearly so. Variations from these directions are often seen, and the E. & W. joints occur along the whole of the eastern escarpment; but my own observations agree as to the general direction of the lines of joint with those above quoted. The general and most simple appearance of a joint is merely that of a crack passing nearly perpendicularly through a rock which is of similar character on both sides; but the variations are frequent; and of these a few instances will be given. The joints vary in width from a line to an opening of several inches, where the decay has been great; and in mineral veins, if they ought to be regarded as occupying joints, the width will often be several feet. The joints vary from the perpendicular; and the east and west joints incline more than the north and south; and there is no rule as to the direction of the inclination. Sometimes there is a difference in the character of the granite on the opposite sides of a joint. A vein of decaying granite occasionally occurs between compact masses of granite of similar character; a vein at Carrion Hill, near Moreton Hampstead, is an example of this; but veins of decaying granite, with hard rock adjoining, often occur, which are not apparently connected with joints. An example may be seen in the cutting to the south of Lustleigh station. A series of parallel joints may occasionally be noticed with a few inches only of rock between them; and though these portions of rock are alike in general character, the felspar crystals in each will be placed in different positions. The connexion of joints with mineral veins will not be entered upon, except to notice that the joint not unfrequently passes nearly along the centre of a vein of felspar, where it is marked by a black line of fine schorl, in which case the felspar is of a pink colour. Several of these variations may be seen in the weathered cutting on Mill Hill, near Chagford. The character of the granite by the side of the joints (as mentioned in Report, page 190) occasionally appears to be altered; on the surface it is black, often from schorl, and presents a tessellated appearance, caused by minute cracks, which penetrate about an inch deep into the rock. If this coating is removed, the unaltered granite of the district will be seen below. Examples may be seen near Chagford, at Lower Murchington, Mill Hill, and about a quarter of a mile from the town by the side of the road to Moreton. Minor lines of joint, extending only over small areas, occur occasionally. These cross at rather acute angles; and when the sides of these minor lines of joint have been altered as above mentioned, the granite presents a basaltiform appearance, which, if not carefully examined, may mislead. A good enample may be seen at the base of the north end of West Hey Tor, where the basaltiform beds form a stratum only a few feet in thickness, but many of the joints extend upwards into the overlying rock. These joints are perpendicular.

A slight inspection of a tor will in most cases show that the form in which it now appears is caused by lines of joint. In those where the granite is crystalline and hard, as at Yes Tor, East Mill Tor, Belstone Range, Wattern Tors, and others, this is very apparent; but

Fig. 1.—*South side of North end of Belstone Tors, showing ends of North and South Joints and Dip of Granite to the West.*



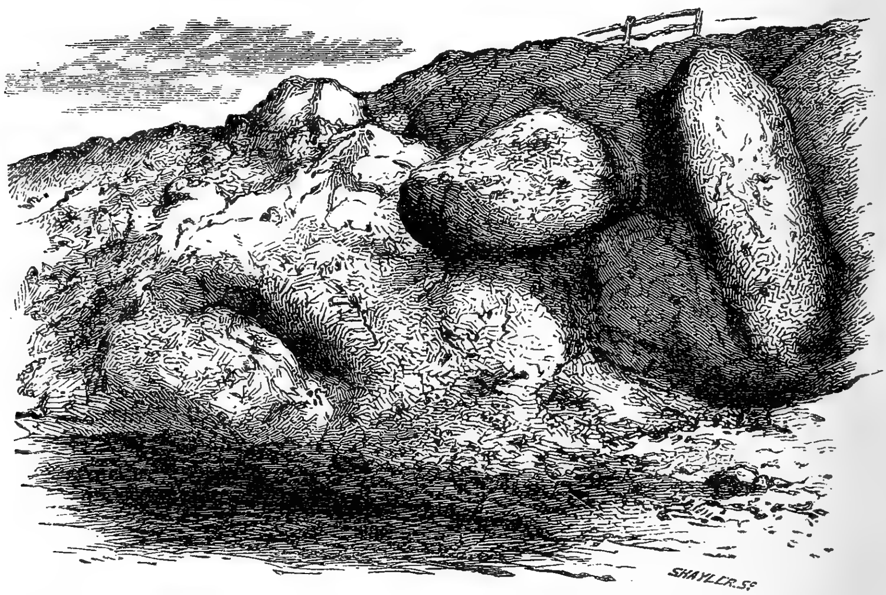
in some cases, as at Kestor, where the granite is not very compact, and is subject to decay, this, though not so obvious, is soon detected. A Dartmoor tor consists sometimes of a solitary rock, though more frequently of distinct but associated masses, rising from the same bed or boss of granite. At the tors composed of associated masses, the form of each division can be generally traced with ease to the influence of the joints, and the line followed from rock to rock. At Hound Tor this is well shown. The tor is divided into three portions by a wide opening which traverses it from west to east, and is crossed at part of the eastern extremity by another opening ranging nearly from north to south. There are low broken cliffs on both sides of the east and west opening; and on the south side of it the oblique beds mentioned by Mr. Mackintosh (Q. J. G. S. xxiv. p. 279) are well exposed. Great Mistor, on the western edge of the moor, is divided in a similar manner by a wide opening ranging from N. to S., with low cliffs at the side. Fur Tor, near the centre of the moor, is a fine example of an associated tor. Hey Tor is divided into East and West Hey Tor by a wide opening which runs nearly from N. to S. At East Hey Tor the east and west joints are very clearly shown dividing it into distinct blocks. It may here be mentioned that it does not appear that these wide openings were caused by the decay of soft rock. Occasionally, as at Hey Tor, the rock that underlies the opening is exposed; and when that is the case it is generally found that the beds of which it consists are continuous from the adjoining tors. The solitary tors will in most cases be found to have been once connected with others in the same vicinity, though now so far apart that they are known by separate names. Thus Yes Tor is a solitary tor, bounded on two sides by lines of north and south joint, and with the east and west lines easily traceable. This and High Willhayse, about half a mile to the south, and some other smaller rocks, once doubtless formed part of the same field of granite. Kestor and Middletor, solitary tors distant about half a mile, mark the places to which the granite extended before it curved down to the N. & S., as before mentioned. At Wattern tor (fig. 2),

Fig. 2.—*Wattern Tor, from the South, showing the decay along the lines of North and South Joints.*

the chief mass is crossed by two north and south lines, along which decay has acted, dividing the upper part into three masses, and forming one of the most imposing tors on the moor. To the N.E. of this tor there is a narrow ridge with low cliffs on both sides, formed by parallel N. & S. lines of joint; and at one place, in consequence of decay along the E. & W. joint, the storms have forced a passage, whence the tor has derived the name of Thirlstone. The E. & W. joints here are not perpendicular, but incline towards the south; at Honey-bag Tor, near Widdicombe, in the moor, the inclination is towards the north. Near Manaton, on a hillside, there is a solitary tor, "Bowerman's Nose," rising about 40 feet above a "clatter of rocks;" its prismatic shape is probably derived from the intersection of lines of joint. These tors have been selected from many as a series of examples of the effect of lines of joint, tracing it from the large massive cluster of rocks to the insulated pillar. Belstone Tors in the hard granite, and Hound Tor in the softer granite, are probably two of the best points for studying the lines of joint, and the different varieties of bedding, and decay along the lines of bedding, that occur in the east of Dartmoor.

It has been before noticed that the granite at the northern part of Dartmoor is more crystalline and compact than that to the south of the North Teign; in the last-named district is the broad belt extending across Dartmoor mentioned in my paper on Rock Basins, as containing those hollows (Q. J. G. S. xv. p. 16). In this south-eastern division, in addition to the other sources of decay, is one that arises from the spheroidal structure of the granite. Professor Warington Smyth, in his Presidential Address for 1868 (page l.), mentions that in Palestine blocks of granite decay from the centre to the surface, giving rise to rounded hollows. That species of decay I have not noticed on Dartmoor (unless perhaps the primary hollows of the rock basins have been caused by it), but the converse takes place; the adjoining rock decays, and spheroidal masses are left. At Furlong, near Chagford, sections of the spheroidal masses are seen in large-grained but tolerably compact granite, in the face of an old quarry; and in the adjoining field, on a knoll where the granite is disintegrating, the upper parts of two globular masses are well shown, one highly felspathic, and in a state of decay, the other still retaining the external coating. A very fine example of a section of the same in decaying granite was, until this month (March 1869), visible by the roadside between Rushford and Chagford, but is now hidden by a wall. In these cases the spheroidal masses are still *in situ*. By the side of the Moreton and South Devon Railway, north of Casley Cutting, there are three distinct disk-shaped blocks of hard rock, evidently once forming parts of the same bed; they are supported on pedestals of soft decaying granite. Almost opposite to the Lustleigh Station, on the same line, are the finest examples of spheroidal masses *in situ* with which I am acquainted (fig. 3); these have already been described by Mr. Mackintosh in the paper to which reference has already been made. As remarked by Mr. Mackintosh, it is probable that from this action many of the supposed boulders in the neighbourhood of Lustleigh

Fig. 3.—*Decaying Granite, showing* in situ *blocks resembling Boulders, near Lustleigh Station, Moreton Hampstead Railway.*



have originated, the blocks possibly not being far removed from the spots that they occupied when *in situ*. To this cause probably also may be ascribed the shape of various large insulated rocks found in the district where this spheroidal structure is so apparent, such as the large rocks in the Rushford Woods near Chagford, Willistone rocks near the Teign north of Moreton, and the Parson's Brown Loaf near Lustleigh Rectory.

In noticing the effects that bedding, joints, and spheroidal structure have had, and now have, it has been necessary to touch on each separately; but it is scarcely needful to say that these three causes are constantly acting together. The action of joints in dividing the masses which have since become isolated, and of decay penetrating between the stratiform blocks, have doubtless shaped the rocks that form the Cheese Ring and similar places. To the joint action of all three causes may probably be attributed the Logan or Rocking Stones of the east of Dartmoor, at Belstone, and Thornworthy, and to that of bedding and joints, probably, that on Rippon Tor; the stones that form these three Logans are probably *in situ*. The Drewsteignton Logan in the Teign is of compact, hard, angular felspathic granite, and rests upon granite; it is in the Carbonaceous district, about a quarter of a mile to the east of the point where the Dartmoor granite ceases: it is not *in situ*; and the amount of large felspar crystals contained in the stone lead to the opinion that it has not formed part of any of the numerous granite and elvan veins which in that locality penetrate the Carbonaceous rocks. The well-known "Nutcracker," the Logan in Lustleigh Cleave, is on the side of the hill, and is not *in situ*; it is apparently a block of granite which has rolled down from above and fallen into a position in which it could be easily moved. This Logan was wantonly thrown out of balance a few years since, but has now been replaced. Another Logan of similar character is almost close to the "Nutcracker." A further examination has shown that the rocks at Leigh Bridge described by the author at p. 419 of vol. xxiii. of the 'Quarterly Journal' as "masses of granite piled on each other," are *in situ*. This appearance is due to the north and south lines of joint and spheroidal structure.

In this paper attention has been directed solely to the bedding, joints, and decay from spheroidal structure which appear in times past to have been, and which now are, active agents in producing the disintegration of the granite, of which the effects are so apparent; doubtless the varied manner in which the rocks have been acted upon arises in a great degree from the peculiar mineralogical character of each district; but this is a point on which I much regret that it is not in my power to give reliable information.

It has been needful occasionally to go over ground which has already been partly described by others; and in those cases it has been endeavoured to incorporate the opinions and observations of the various authors in their own words.

Discussion.

Prof. Ansted had observed similar conditions in Leicestershire, Alderney, and elsewhere. The most important feature in the case was the amount of subaërial disintegration and denudation to which the rocks, and especially the Tors, bore witness. The bedding pointed to the metamorphic character of granite; and in some parts of Corsica this was still more plainly shown than in Devonshire.

Mr. W. W. Smyth agreed that the disintegration of granite was mainly due to the causes pointed out by the author. He did not, however, regard them as *entirely* resulting from subaërial denudation acting on a surface of uniform quality. There was probably a difference in the proportions of the constituent parts in the granite, some parts in the same quarry being soft while others were of extreme hardness. These softer parts were easily removed, while the harder parts were left. The question was, whether this difference was the result of the original deposition or of subsequent segregation. Even where china clay resulted from the decomposition of the rock, some of the nodules of harder granite occurred.

Prof. Brayley remarked that the subject of the spheroidal structure of some of the crystalline rocks was of much importance in geological physics. He believed he had been the first to call attention (Phil. Mag. 1830) to the connexion of rock-basins with that structure as existing in granite. The phenomena at Karn Brê in Cornwall were much the same as on Dartmoor, and resulted, originally, from the concealed spheroidal structure of the rock, or rather from what he might term a spheroidal tension. In Mount-Sorrel syenite and Northumberland basalt the same was to be traced; and Rowley Rag exhibited the effect of the spheroidal tension, as developed by weathering, in the most perfect manner.

Mr. Scott stated that in the granite district near Dublin isolated blocks, deeply weathered, like the tors described in the paper, were met with. The granite itself contains masses of a harder nature than the surrounding rock, which are usually enveloped in a coating of black mica. In the stratified granites of Donegal and Argyllshire such a structure had never been noticed by him.

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2. Notes *on* Apparent Lithodomous Perforations *in* North-west Lancashire. By D. Mackintosh, Esq., F.G.S.

[Abridged.]

The author, after referring to the discovery of perforations in limestone rocks, at various altitudes above the sea, by Mr. Pengelly in Devonshire and Mr. Darbishire in North Wales, proceeded to describe the character and mode of occurrence of those he lately observed near the shores of Morecambe Bay. They were stated to be most numerous in the neighbourhood of Great Urswick, at altitudes of between 200 and 300 feet; but after a persevering search he found them on the eastern or Grange side of Hampsfell up to 667 feet above the sea. "They occur in limestone rocks of varying structure.... They have been excavated irrespectively of any hardness or softness of the rock, and of any susceptibility to decay in one part of the rock more than another. Their circumference runs continuously through portions of rock of varying composition," and the holes often run into and through fossils.

Mr. Mackintosh believed that a minute study of the actual effects of rain and other atmospheric agents would convince any one that these perforations were not the result of weathering. "The pits, holes, or crevices produced by chemical decomposition, or the slight mechanical action of rain-drops *, are either rough or present no regularity of outline, and they always conform to the varying composition and structure of the rock. The distinction between the perforations under notice and all other indentations in limestone rocks is obvious." In one large specimen Mr. Mackintosh noticed that the perforations were more circular, smooth, and cleanly cut than a hole made by an iron borer, which happened to be in the same slab of rock. "They all present a uniformity of pattern irrespectively of the character of the rock. They generally occur in groups, which often ramify from a large shallow entrance or lobby. In most cases the mouths of the holes would appear to have been either fractured off by frost or in some other way destroyed; but instances have been found in which they have been preserved, and then the mouths are seen to be smaller than the interior of the holes. They frequently exhibit circular striæ, as if excavated by a rotating, or partially rotating, agency. The perforations have been *ground* out by some cause as evidently as any rock-surface has been subjected to a grinding process. . . . . They are associated with smoothly hollowed, rounded, and funnelled rock-surfaces which run under the drifts of the limestone districts of North-west Lancashire."

In conclusion, the author expressed his belief that the holes were ground out by some animal while the land was submerged, either before, during, or after the Glacial period.

P.S. Very lately (July 1869) I have found numerous similar perforations at altitudes between 1000 and 1400 feet above the sea, near Buxton, the most perfectly preserved (about seven-eighths of an inch in diameter, and often 3½ inches long) occurring on the steep or south-west side of Hill-head Valley, about a mile S.E. of Parks Inn.—D. M.

Discussion.

Mr. Gwyn Jeffreys remarked that Mr. A. Tylor had already called attention to the same subject three years ago. He could not agree in regarding the perforations as made by any mollusk or other animal. The borings of *Pholas*, *Saxicava*, and *Gastrochæna* were not parallel, but enlarged towards the base into a pear-shaped form. They were also comparatively straight, and not curved or bifurcated as in the limestones exhibited. The range in height was also against their being the work of marine mollusks. He thought the perforations were more probably due to atmospheric agency.

Prof. Ansted had seen in the large blocks of the Cyclopean walls of

* "The holes generally open downwards, or horizontally, on the protected sides of projecting ledges or blocks, in situations to which rain has little or no access."

Greece holes of various sizes bored to different depths by the combined action of vegetation and atmospheric influences. In some cases these holes were large enough to receive the arm, and were two or three feet in length.

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3. *On the* Origin *of the* Parallel Roads *of* Glen Roy. By James Nicol, Esq., F.R.S.E., F.G.S., Professor of Natural History in the University of Aberdeen.

The general characters and appearance of these celebrated roads are so well known as scarcely to require to be mentioned. Running apparently with perfect horizontality and complete parallelism along the two sides of a long Highland glen, turning up every lateral valley and encircling every hill, they form a spectacle altogether unique in this country, and which, when once seen, can never be forgotten. Their mode of origin, on the other hand, still remains one of the open, undecided questions in Scottish geology. Various theories have been proposed, each enjoying popularity for a time, but no one permanently remaining master of the field. The horizontality, parallelism, and general character of the lines leave no doubt that they have been formed by water standing at the level of each line or road for a very considerable period, and then suddenly subsiding to the level of the next lower road. Thus far all recent observers seem agreed. But fresh water and salt—mountain loch and sea-firth—have still each their own supporters; and some who once advocated the one of these views, may now be found supporting the other. It is thus evident that no facts very decisively in favour of either theory have yet been adduced. But that such facts do exist I hope to be able to show in the following observations, and thus to contribute some evidence tending to decide this question.

As the general aspect and characters of these lines or roads are so well known, and have been so often and accurately described, I shall abstain from referring to them as far as possible. My remarks also have reference to the rival theories generally, and not to any special view or defence of them, and I have therefore avoided all reference to the writings of former observers, and all criticism or remark on their arguments. With very few (and these easily understood) exceptions, the facts stated are only such as I have personally verified during my repeated visits to the country where the lines occur.

Two rival theories as to the cause and origin of these lines at present prevail among scientific men. One party considers them ancient sea-margins, left behind as the land rose, or, as it may be otherwise expressed, when the sea retired. The other party ascribe them to fresh-water lakes which formerly filled the valleys and were drained at intervals, as the barriers, of ice or detritus, that shut in these lakes, were suddenly dissolved or broken down. I adopt the first or marine theory, and therefore am not much concerned in the special arguments for or against the two varieties of the lake-theory.

Whatever view we may take of the origin of these lines, one great fact seems beyond dispute. Long before they originated, the country in which they lie must have had nearly its present form and outline—the same hills and mountains, the same glens and valleys, with nearly their present relative elevations. This fact we may, or rather must, assume in all our reasonings and speculations. This region has also been subjected to a very extensive glacial action. Wherever the rocks are newly exposed they are marked by grooves and striæ. The direction of these striæ and the form of the rounded rocks show that in a few cases the ice has come down some of the lateral valleys and moved towards the west. But other facts appear to me to indicate that here, as in other parts of the North of Scotland, the great ice-stream has flowed from the west, and probably from a lofty mountain-chain that then existed in that region.

Subsequent to this ice-period, but before the formation of the Glen-Roy lines, the whole region has been submerged in the sea. This is proved by the uniform coat of detritus covering the whole surface, in a thicker or thinner sheet according to the form of the ground. This coat is not the mere surface waste, but matter laid down by water, and is too widespread and general in its distribution, and too much mixed in its composition, to have been formed in any mere lake. Associated with it are numerous boulders of travelled stones, some of them imbedded in its mass, others lying on the surface. As examples of these I may mention some huge blocks of black granite and other smaller masses of red porphyry which occur within a few yards of the summit of Craig Dhu, a conical mountain of mica slate, that rises to more than 2000 feet above the sea, in the angle between the valleys of the Spean and Roy. One block must weigh about forty tons; and they are evidently ice-borne masses, floated probably far from the west in the ancient ocean.

It is in this detrital cover that the lines are cut; and the period and mode of its formation are thus of much importance. That it is a marine deposit seems beyond doubt. That it has been formed since the general glacial striation of the land is also proved by the fact that it spreads over the rocks marked in this manner. This is well seen in the Spean valley in very many places. More convincing, or at least more interesting, is the fact that in Glen Roy these striated rocks occur immediately under the lines. The old line or parallel road now passes over the rock-surface that in a former period was worn and striated by the glacier. There is thus the most direct proof that the period of general ice-striation was separated from that of the formation of the lines, by a period in which the land was submerged in the ocean and its general cover of detritus deposited.

This fact, however, does not decide the mode of formation of the lines, or even its relation to ice and glaciers. There is abundant evidence in many parts of Scotland that the great western glaciation has been followed by more limited and local ice-action. Even on the same rock-surface two intersecting sets of striæ may be seen, the older set quite independent of the present outline of the country, the newer clearly determined by the existing mountain-valleys and glens. It is quite possible that, after the land emerged from the sea, ice may have again formed in the mountain-corries and flowed in vast rivers down the glens. There is, indeed, evidence that this has occurred, in at least the higher portions of the district. But we must ever be careful to avoid confusing these mere local and partial glaciers, very limited both in size and influence, with the far older and more universal ice-action of the first period. The earlier glaciers can have had no connexion with the origin of the lines; the later may.

When examining the lines on various occasions, I have ever been on the search for some fact or facts that might serve as a criterion of the truth or falsehood of the rival theories. At one time I thought the character of the shingle composing them, and the mode of its deposition, might serve this purpose. But I could find no character of this kind at all satisfactory. The shingle on the shores of our Highland fresh-water lakes and that on those of the inland salt-water lochs, are too similar in most respects to admit of accurate discrimination. At length one character did occur to me of a testing and discriminating kind, one point in which the two views were essentially different. Mr. Milne long ago pointed out the remarkable fact that the three best-marked lines corresponded nearly with cols or gorges between the hills, and showed that these gorges must have formed the outlets for the fresh-water lakes to which he ascribed the cutting out of the lines. Now of this there can be no doubt. If from any cause the water of the Spean was prevented from flowing off to the west till it rose to the height of the first or lower line, it would form a lake flowing off to the Spey by the pass of Maccoul; so also a barrier raising the waters of the Roy to the second line would cause them to overflow by Glen Glaister; and were this exit also shut, when they rose to the third or highest line they would then escape at the very top of Glen Roy into the Spey. How far the levels of the respective lines correspond exactly with these cols must be left to the Ordnance Survey to decide. The levels are either very near, or perhaps the lines in some cases a little higher; so that the supposed lakes would necessarily have overflowed at the points mentioned.

It is thus certain that, if the lines were formed by fresh-water lakes, each of these passes must have been the exit of a river of very considerable size and flowing in a narrow valley for a long period. If, on the other hand, they are of marine origin, then these same passes were sea-straits—narrow channels connecting one great bay with another. Here then was a marked difference in the two theories, a matter of fact which existing phenomena might enable us to decide. For this purpose I examined the various passes carefully, and found that whilst in none of them was there the slightest trace of an ancient river, in all there were distinct indications of the former existence of a narrow sea-strait. Here, then, it appears to me we have undoubted proof that the lines have been formed by the sea, and not by lakes.

A few observations taken from notes made on the spot may render this statement plainer. The highest line is that in Glen Gloy. The valley by which the lake is assumed to have drained into Glen Roy is very narrow and encumbered with detritus from the hills on the sides. The summit-level is flat and marshy, and it appeared to me considerably below the level of the line. On the other hand, a line of stones, as if washed out of the detritus, appeared to show that the sea or loch had extended quite through the strait. I observed no indication of any stream of water larger than the present small rivulet having ever run here. But as the difference in height of this line from the upper line in Glen Roy is not great, and the erosive action of the river might thus have been limited, I shall not mention any other details.

The next pass is that from Glen Roy to the Spey. If a lake ever filled the valley of the Roy to the level of the upper line, a great river, fully equal to the Roy where it now joins the Spean, must have flowed through this pass. In time of floods, when swollen by the western rains and melting snows and glacier-ice, it ought to have left no uncertain mark of its passage over the watershed and down the valley of the Spey; but I looked in vain for any indication of the former presence of such a mighty stream. It has cut no notch in the ridge or on the sloping declivity to Loch Spey; it has formed no delta in this lonely tarn. The broad flat strath of the Spey shows only the narrow channel through which the present streamlet winds its way to the sea. No one who has ever studied the effects of running water in such situations could doubt that even in a few days or weeks such a river as the present Roy (and the old river at least could not have been smaller) would leave a groove in the soft alluvial hollow which centuries would fail to obliterate. The rapid running stream must have cut a deeper line on the low haugh than the mere wave-wash of a shut-in mountain-lake on the slope of the hill. Yet the one is distinctly visible for miles round and round; of the other there is not the faintest trace. It is a physical impossibility that the lake should have left such a deep and distinct line, and that the river should have flowed through the gorge and down the valley for the same time without leaving any mark of its presence.

On the other hand there are clear indications of the pass having once been a sea-strait. The bottom is broad and flat; a notch is cut horizontally along the side of the hill where the water once stood, and a distinct line of stones left where the water has washed away the detritus. In other words, there is an old wave-washed beach. Then a curious series of little rounded bare knolls rise up in the old channel. From a lateral corry below Loch Spey great masses of detritus project into the main valley, but these are spread out and levelled down; as if thrown into the sea, not as if heaped up in a river-valley. It is scarcely worth mentioning, though important in reference to the glacial form of the lake theory, that even in the end of August the snow was still lying unmelted in the corries to the south; hence any climatal conditions that would produce glaciers on Ben Nevis capable of damming up the valleys of the Roy and Spean, would have also sufficed to fill this lofty valley with an ice barrier. If ice prevented the water flowing west through the Spean, it ought also to have prevented its flowing east into the Spey.

The next point of assumed overflow, when the lake stood on the level of the second line, is the col at the top of Glen Glaister. This is very nearly on the level of the second line, as is easily seen even without instruments. The summit-level is a flat and marshy plain. A small stream that comes down to it from the hill on the south-west, after winding through it in almost stagnant pools, at length flows off to the Spean by the Rough Glen. The declivity here is very considerable, and the consequent rapidity and cutting-power of a river flowing down it must have been very great; yet no trace of such a river appears. There is only the narrow channel of the present small rivulet. A little below the watershed it crosses a ridge of low rocks; but even there no indication of a larger stream is visible. According to the lake theory, the Roy once ran down this glen, as it now runs in the bottom of its own glen. We have only to compare the deep, well-defined notch or gorge which the river has cut for itself from the mouth of Glen Glaister to the Spean with the unbroken outline of its so-called old course, to be convinced that no river has ever passed through the Glen-Glaister col. It is very remarkable that though there is no evidence of a former river, there is evidence of a shore-line on the level, not of the second, but of the higher line. A well-marked beach of washed stones can be traced along the side of the hill on the east quite through the pass. This shows that no barrier, damming up the water to the level of the higher line, existed in this place at the time when that line was forming.

It is evident from the distinctness of the lines that the fall of the water from the level of one to the level of the next lower, has been on the whole sudden. On the lake theory, the fall from the upper, Glen-Roy line to the second line was caused by the breaking down of the barrier of detritus or ice shutting up the Glen-Glaister col. But by removing that barrier, a depth of water of from 80 to 100 feet would be set free over the whole surface of the Glen-Roy lake, with an extent of ten miles in length by above one mile in width. All this enormous mass of water would be emptied out in a few hours, or, at most, days. With what rapidity and what results such a mass of water would escape may be imagined by any one who has read the accounts of the bursting of the far smaller ice-lake in the valley of the Dranse. If we wish for instances nearer home, the accounts of the bursting of the Bilberry reservoir in 1852, or of that of Dale Dike, near Sheffield, in 1864, will show the enormous devastation and erosion a far inferior mass of water suddenly let loose can occasion. A few sentences must be borrowed from the engineer's report on the latter:—"Everything solid which stood in the direct course of the flood was swept away; huge rocks were torn up and were floated along, just as pine timber would have been floated in an ordinary waterway. One of these stones so floated weighs upwards of thirty tons, and is in dimensions not unlike one of the largest stones at Stonehenge. Hundreds of tons of smaller stones were torn up and swept along. Of the first mills encountered by the flood, not a vestige remains to show where they stood—the buildings, site, and subsoil (rock and shale) having been scooped out and swept away, as also the ground for a considerable distance around" . . . . .

If such results followed on the sudden drainage of a small reservoir, can we believe that the water in the upper Glen-Roy lake, to a greater depth and covering nearly a hundred times the extent of surface, all passed away down a steep and by no means wide valley, without leaving behind any trace of its passage?

The next point of supposed lake-drainage is the Pass of Maccoul, between Loch Laggan and the Spey. This pass is a narrow ravine with a flat bottom and a very slight declivity from the watershed either to Loch Laggan or the Spey. A river might thus have flowed through it without leaving any very deep trace behind. It is also much encumbered with peat, which hides and obscures the outline of the ground on which it rests. Hence though I observed no indications of an old river in this locality, I put less value on the negative evidence thus furnished. On the other hand it is curious that the river Puttaig, which falls into the pass from the south-west, and which would more naturally have flowed on to the Spey, turns sharply round and runs to Loch Laggan. Had a river from the lake flowed formerly in the other direction, we should have expected the present river to have continued its old course and not to have taken the reverse. The present channel, though not deep, is still well marked, and shows what we might have expected had a much larger river flowed in the other direction. On the other supposition of a sea-channel in this place with the western tidal currents setting through it, it is easy to see how the débris from this stream should be chiefly accumulated to the east, thus compelling the river, when the land rose out of the sea, to turn westwards to Loch Laggan. The evidence to be derived from the facts seen in this locality therefore appears to me altogether in favour of the marine theory; but, for the reasons mentioned, I do not insist on it. This, however, is not necessary. If there is, as I have endeavoured to show, undeniable proof that no lakes ever existed so as to form the higher lines, and that these therefore must have been formed by the sea, no person will seek to ascribe a lake-origin to the lowest of the series.

There seems to me no way of meeting the evidence for the marine origin of these lines, now adduced, except either to deny that rivers flowing in such places and conditions would form such distinct and well-marked channels as I have alleged, or to affirm that such channels and other marks of their existence would soon be obliterated by subsequent changes. But, after studying the action of running water for years, both in the south and north of Scotland, I have no hesitation in affirming that it would be a physical impossibility for a river like the Roy to flow over and down such declivities and leave no notch behind. I have seen a stream which had during a flood changed its course, cut out in a few days a channel which centuries would fail to efface. In uncultivated ground such inequalities of surface are very slowly obliterated. In such places 1500 or 1600 years of neglect have done little to efface the old Roman roads or camps; the still older British hill-circles and vitrified forts are still distinctly marked; and there is no reason to believe these river-beds more perishable. The Glen-Roy lines are the best proof how durable such markings are in such conditions. In Glen Roy itself there is much curious evidence both of the effects of river-action and the durability of the marks it leaves. The delta-terraces formed where the streams fell into the old bays on the level of the lines, as at the entrance to Glen Turrit, were of course immediately cut into by the rivers when laid dry by the retiring of the waters. Many of these old watercourses, which had been cut out by the Turrit and other streams before they finally settled down into their present beds, are still easily seen. Some of these are nearly as old as the line they accompany, and older than the lower lines—and thus prove that there has been no surface-change here sufficient to obliterate the former river-channels, had they ever existed.

I might now leave the question to be decided on the evidence adduced; but there are a few other facts corroborating the same views that may be mentioned. And first, though these lines are in some respects unique in character, there are other indications of the former presence of the sea in this region. Thus in the valley of the Spean there is, as it were, a continuous series of terraces continuing the lines at intervals down to the sea-level. Such wide terraces, or shingle beaches, are well seen along the Spean from Roy Bridge downwards. Another similar terrace is seen at the mouth of Loch Treig on the level of the third or lower line. The sea has stood here for a long period, as the hills above this sheet of detritus are washed very bare, and in some places a well-marked shore-cliff has been cut immediately above it. The detritus here, however, has not come down Loch Treig, as might at first sight be imagined, but from the Corry Laire to the west, and has then been swept eastwards by the tidal currents, and even up into Loch Treig, on which it abuts with a bold, almost vertical end. In many other places in this part of Glen Spean there is similar evidence of a current from the west flowing up the valley. Thus the lower or western sides of the knolls and rocks are bare, and the detritus accumulated in long mounds or tails behind (that is, above them) to the east. This could not have occurred in an inland lake, where there are no currents, but must have taken place in a marine channel open from sea to sea.

Further, there is a vast amount of evidence of the former presence of the sea at various levels between the upper and lower Glen-Roy lines in all the surrounding region. This evidence also is specially distinct in the valley of the Spey, and thus on the other side of the watershed and in the very valleys into which the lakes are said to have drained. This is most remarkably the case in the upper valley of the Spey above Laggan. I have already mentioned the great terrace-mound at the lower extremity of Loch Spey, and nearly on the level of the upper line in Glen Roy. Another very distinct terrace is seen near Garviemore, probably not far from the level of the second line. This terrace much resembles the one at Inverlaire near Loch Treig, but is on a different level. There is another similar flat mound near Glen-Shira Lodge, with a line of washed stones on the hillside, evidently marking a former beach-line.

Still lower down the main valley and in that of the Truim, followed by the Highland Railway, similar indications of the former presence of the sea are very striking. Kingussie, 762 feet above the sea, is about 80 feet under the lowest Glen-Roy line; whilst Dalwhinnie Inn, 1182 feet high, is 40 feet above the highest. In the space between, marks of horizontal lines and terraces are very conspicuous. Thus at the north end of Loch Ericht, a little below Dalwhinnie, and nearly on the level of the upper line, there is a great shingle-deposit of round water-worn stones, showing that the sea has long stood at this elevation. Singularly enough, this old beach forms the watershed between the Spey and Tay in this place. Another very strongly marked terrace is seen for miles on both sides of the Spey near Kingussie. It is about 820 feet above the sea, and thus rather lower than the third Glen-Roy line (about 30 feet). This difference of level is very small, considering that Kingussie is 30 miles from Glen Roy in a direct line, and 15 from Loch Laggan, where the lowest line terminates in the Spean valley. The breadth of this terrace, the flatness of the surface, broken from place to place by deep irregular hollows with pools of water at the bottom, and the distinct cliff where it meets the slope of the hill, prove that the sea has stood here for a long time. At Loch Gynac, a small lake in the valley behind Kingussie, there are three terraces quite similar to those in Glen Roy, but far inferior in extent. Two of them also, according to some aneroid observations I made, are nearly on the level of the second and third, or upper terraces in Glen Roy. There are other similar indications of the presence of the sea in this vicinity; but I shall only refer to some distinct traces of horizontal lines on the declivity of the hill forming the south side of the Laggan valley on the Spey. In regard to all these lines and terraces in this district, they appeared to me to show that the water had retired, or the land risen, by sudden starts, as it were, not by a slow, regular, and continuous process. In this they agree with the phenomena of Glen Roy, and thus confirm the view now given of the origin of its lines.

The exact coincidence of the lines with certain cols or passes between the valleys has to many appeared an almost insuperable difficulty in the way of the theory of their marine origin. It has been felt as a strong objection to this marine theory, that the sea in its descent should pause three or four times, just at the level of these three or four openings in the hills. It may lessen this difficulty if we consider that the currents from the west, flowing through the old channels, would tend to cut them down to these levels; whilst the sudden rise of the land would stop the further continuation of the process. It is also important to remark that at all these points a stream enters the main valley from the side, or from a lateral valley, and thus, by the débris it would bring down and deposit at its mouth, would tend to fill up the main valley to the level of the line. This is very markedly the case with the pass of Maccoul and that of Glen Glaister. It may also be noted that such coincidences of the lines with hollows between the hills are seen in other places. Such is that already mentioned of the coincidence of the upper line with the level of Loch Ericht and the watershed between the basins of the Spey and the Tay.

But it must be remembered also that difficulties do not affect only this theory. Perhaps the combination of the various conditions needed to shut and open the lake-barriers exactly at the right time and in the proper order are not more probable. If these lake-barriers were formed of detritus, its collection and sudden removal is no less inexplicable. Ice-barriers may seem more manageable, but are subject to no less inexorable conditions of climate and elevation. A glacier that would fill the valley of the Spean and Roy with a mass of ice 800 or 1000 feet thick, and some miles in extent, would require an extent of feeding-ground that is not easily found in this region. I have never heard of a lake of such depth shut in by ice in any part of the earth at the present time. To form an embankment for a water reservoir of one-fourth the depth and one-tenth the extent of the supposed Glen-Roy lakes, with the best materials he can select, is no mean task for an engineer of the present day. What would he think of the task were he required to build the barrier of a material of less specific gravity than the water to be shut in, of a material which that water and the ground on which it rests were constantly corroding and wasting away, so that his barrier had to be incessantly moving forward from behind to compensate for what it lost in front? To form a permanent lake with a uniform level on such conditions has, I must confess, always appeared to me an almost impossible problem, far outweighing any difficulties that attach to the marine theory.

But all such considerations may be laid aside. The chief and fatal objection to the lake-theory is that it supposes rivers to have flowed in places where there is clear proof that no river has ever flowed,—that it assumes a great lake to have been suddenly drained by a narrow glen where it is undoubted no stream of water, larger or more rapid than the tiny rill gathered from the sides of the neighbouring mountain, has ever existed since the ocean laid down the loose soil spread over its smooth unbroken declivities. The theory not only fails to explain the phenomena, but is in direct contradiction to them, and therefore must be rejected.

Discussion.

Mr. Gwyn Jeffreys observed that no organic remains appear to have been found in these beaches, so as to prove their marine origin.

Mr. Evans agreed with the author as to the difficulties presented by the Lake theory in accounting for the terraces, especially those not in Glen Roy itself, but in the valley of the Spean. He called attention to the part which sheep and other animals had played in the preservation of the Parallel Roads, the vegetation on which, in consequence of their being more frequented by the animals, was of a different character from that on the other parts of the slope.

Mr. H. M. Jenkins objected to the supposition of the sudden alteration in the level of the water adopted by the author. He thought the gradual sinking of the water was quite compatible with the formation of the roads. He instanced the formation of terraces in gravel-pits filled with water.

Sir H. James announced that the Ordnance survey of the district in question was now complete.

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4. *On* Beds *of supposed* Rothliegende Age, *near* Knaresborough, *&c.* By J. Clifton Ward, Esq., F.G.S., of the Geological Survey of England and Wales.

By permission of the Director-General of the Geological Survey I am enabled to lay before the Society a brief outline of some observations made during the past summer in the course of my professional duties.

In the neighbourhood of Knaresborough occur certain very well-marked and distinctive grits of a red or purplish-red colour; for the most part these rocks are coarse, frequently quite conglomeratic; oftentimes, however, they are mere sandstones, while in some places they pass into sandy shales. In some localities, as near Plumpton, the proportion of red felspar in the grit is very great, while in others white specks of decomposed mineral matter are scattered profusely through the mass. The quartz-pebbles are very often as large as pigeons' eggs, and form well-marked layers, generally at the base of the separate beds of grit.

The grit in the neighbourhood of Plumpton, near Knaresborough, forms most picturesque weathered masses. Between Spofforth and Plumpton, on the slope immediately below the magnesian-limestone escarpment, stand numerous detached pillars and masses of rock, some rising 15 feet above the level of the surrounding ground, others but barely protruding, their surfaces presenting all those curiosities of atmospheric action, in the shape of perforations, basin-holes, honeycombing along the planes of bedding, &c., which, although in many cases difficult to explain fully, yet seem still to be in process of forming. The soil of the fields in which these detached and picturesque rocks rise consists, as one would expect, of the decomposed grit, and seems of a very shifting nature.

On the age of this Plumpton grit I wish now to offer a few remarks. By some geologists it has been described as Permian and the equivalent of the Rothliegende of the Germans; by others it has been assigned to the millstone-grit series.

1. *Authorities for Permian Age.*—Prof. Sedgwick (in his paper upon the magnesian-limestone series in vol. iii. of the 'Transactions' of this Society) speaks of these rocks as forming the base of

the Permian, and calls them the "Lower Red Sandstone." At first he believed them to belong to the underlying millstone grit, but subsequently changed his mind upon this point. The grit (exposed by denudation) under the magnesian limestone in Bramham Park he also assigns to the Permian, though he has not failed to observe the unconformity that exists between these "Lower-Red-Sandstone" beds and the magnesian limestone proper.

Prof. Phillips (in a paper entitled "Notes on the Geology of Harrogate," Quart. Journ. Geol. Soc. vol. xxi. p. 234) also assigns the Plumpton grit to the Permian series, and speaks of it in the following words:—"The rock is often quite undistinguishable from millstone grit in hand specimens; even the purple colour (due to decomposed ferruginous mica) fails sometimes. . . . . . As we proceed to the south, and reach the Leeds coal-basin, the Permian beds lose their similitude to millstone grit; and as we pass to the north and encounter the mountain-limestone, so also the resemblance to mill-stone grit is lost, nor is it recovered in Durham or Northumberland, nor does it occur in any other part of the kingdom, though quartzose pebbles and coarse sand accompany it in many parts." The grit on Bramham Moor, however, Prof. Phillips excludes from the Permians, and he also bears witness to the unconformability of the magnesian limestone to the so-called "Lower Red Sandstone."

Sir Roderick Murchison (on p. 349 of 'Siluria,' 3rd ed.) speaks of the Plumpton rocks, near Harrogate, being "identical with the quartz-conglomerates of Germany, whether as regards their ingredients, colour, false bedding, or massive stratification."

2. *Authorities for Millstone-grit Age.*—Mr. Binney (in an article in the 'Geol. Mag.' for Feb. 1866) inclines strongly to the belief of the millstone-grit age of these rocks, both on the ground of their apparent conformability to the rocks below them, and of the character of the fossil plants which they contain; while he draws attention to the peculiar circumstance of Permian Lower Red Sandtone having millstone-grit characters solely in a neighbourhood where it overlies the millstone grit.

In a paper by the Rev. John Stanley Tute on the "Geology of the Neighbourhood of Ripon," read before the West-Riding Geological and Polytechnic Society, the red grits below the magnesian limestone are spoken of as being debateable ground; but the author's views are in favour of their belonging to the millstone-grit series, into which he says they seem to pass gradually.

3. *Nature of Beds immediately underlying the Magnesian Limestone from east of Leeds northwards.*—East of Leeds the Coal-measures with an easterly strike pass under the unconformable magnesian limestone, the coal at one or two spots being worked beneath it. At Barwick-in-Elmet, immediately beneath the limestone, the shales are micaceous, sandy, and purplish, but these pass gradually down into sandy micaceous shales of the Lower Coal-measures having their usual colour. Just east of the village the little river Cock has cut through the limestone and shown it lying unconformably upon a hard Coal-measure sandstone, close-grained

and flinty, with its joints lined with carbonate of lime. In no spot along the edge of the coal-field immediately east of Leeds have I seen or found recorded in mining-sections any trace of a grit underlying the magnesian limestone.

North and north-west of Barwick-in-Elmet an east and west fault throws out the Coal-measures and brings up the millstone grit, the upper member of which, the Rough Rock, is a coarse and frequently crumbling grit, usually of a yellow colour, and traceable almost without a break eastwards from Meanwood, north of Leeds, to Kidhall Hall on the edge of the magnesian limestone, and again seen in a denudation of the limestone at Bramham Park, where it was taken to be Permian by Prof. Sedgwick. Following the edge of the limestone still further north, the various subdivisions of the Third Grit, with an east and west strike, are successively passed over. Under outliers of magnesian limestone, just south of the river Wharfe and west of Collingham, these grit-beds appear for the first time of a reddish colour in places, and have interbedded purplish micaceous shales; these coloured beds, however, are altogether inseparable from the uncoloured grits, sandstones, and shales occurring further from the borders of the limestone.

The Third-Grit beds across the valley of the Wharfe form a low anticlinal, and on the north side their strike soon changes from an east and west to a northerly direction as far as Plumpton and Knaresborough. The order of succession in the grit-beds near Spofforth is the following. Immediately underlying the limestone is the red and purple grit of Spofforth, Plumpton, and Knaresborough; its top is not seen, but its thickness probably exceeds 100 feet. Below this come some 50 feet or less of such shales as generally occur in the millstone-grit series, followed by a sandstone, gritty in some parts, and generally of a reddish colour, though not so markedly coloured as the last-mentioned grit; this rock, which may average some 75 feet in thickness, passes down into sandy and flaggy shales, in many parts having a tendency to be both gritty and of a purplish tint; they contain also numerous worm- and molluscan tracks, and frequently pass rapidly into beds of hardish stone: a good section of these flaggy beds is seen in the railway-cutting about two miles north-west of Spofforth station; their thickness may be about 50 feet. Next in descending order is a hard sandstone used for road-material, and crowded in some parts with casts of Brachiopods, among the most common of which are *Orthis resupinata* and *Michelini*, *Strophomena analoga*, *Productus*, and *Spiriferina cristata*, determined for me by Mr. Etheridge; the thickness of this bed is about 30 feet. Sixty feet of shale succeed, in turn underlain by what Prof. Phillips has called the "Follifoot coal-grit," for the most part a hard compact sandstone containing a shale-band and thin coal-seam; whole thickness about 50 feet. Then follow some 400 feet of dark shales overlying the Kinder or Fourth Grit, which is underlain by the Yoredale series cropping up as an anticlinal at Harrogate.

The first and second of these beds of grit Prof. Phillips has thought to be Permian.

This order of succession I had already determined when my attention was directed to the paper before mentioned, on the geology of the country near Ripon, by the Rev. John Stanley Tute; the following is the series further north as drawn out by him:—

Red grit of Knaresborough, South Stainley, and Scarah, capping "most of the hills eastward as far as Pateley, and the lower beds of which form the Brimham Rocks."

Cayton-Gill beds, consisting of three beds beneath the red grit. "The uppermost consists of thin flags full of the remains of Encrinites. The second abounds with the casts of Brachiopoda and other organic remains. The lowest is an exceedingly hard and fine sandstone, mottled with carbonaceous markings."

"Arenaceous flags and coal-measures; immediately below these last beds is a series of shales, flags, and sandstones, of considerable thickness, all more or less stained with iron."

The succession of the Cayton-Gill beds below the red grit seemed to me at once to agree with what I had found near Spofforth; and soon after, in company with Mr. Aveline and Mr. Green, I visited these beds north of Ripley; and here we found, as round Spofforth, the first and second beds of red grit, followed by the shell-bed, and this again by the hard Follifoot grit. I afterwards found precisely the same succession just north of Harrogate, the red grit of Knox Farm and Killinghall being succeeded by a hard sandstone containing Encrinites and Brachiopods, striking east and west, with a northerly dip from Four Lane Ends to Saltergate Hill, and having the hard white Follifoot grit dipping regularly under it. During a hurried visit I paid to the celebrated Brimham Rocks, I found on the flanks of the hill below them both the shell-bed and the hard white grit cropping out, thus confirming in my mind the conclusion at which the Rev. Stanley Tute had arrived as to the crags being formed of the lower parts of the Plumpton grit—though here, be it observed, the peculiar red and purple tint is absent. If, now, we sum up the evidence both for and against the Permian age of these red beds, we find—

Against this age:—

1. Their similarity in structure to millstone-grit beds proper, and their complete dissimilarity to beds of supposed Rothliegende age elsewhere in *England*.
2. Their occurrence only in a millstone-grit area.
3. The unconformity of the overlying magnesian limestone to these beds.
4. Their complete conformity to the underlying undoubted millstone-grit rocks.
5. Their containing apparently similar plants to the ordinary millstone-grit beds.
6. Their being of a *red* colour, as is by no means uncommon in grits of the millstone-grit series.

For their Permian age:—

1. Their likeness to certain German Rothliegende conglomerates.
2. Their purplish tint in parts—the colour of many shales and

sandstones generally supposed to be Permian, occurring along the eastern edge of the Yorkshire coal-field immediately below the magnesian limestone.

The first of these two points in favour of a Permian age can go for little, inasmuch as grits and conglomerates of all ages are likely to resemble one another in structure. The second point, however, deserves more consideration, and mainly for two reasons:—

1st. That the purple tint is unusual among millstone-grit beds proper.

2nd. That this is the tint generally assumed by the so-called "Lower-Red-Sandstone" beds immediately beneath the magnesian limestone.

Red grits, as stated before, are not unfrequent in the millstone-grit series; thus, in a section of a bore-hole made on Bradford Moor, the rough rock is termed "Red Sandstone," and in another case "Old Red Sandstone;" while in several parts of the Yorkshire millstone-grit area between the Lancashire and Yorkshire coal-fields, various members of the grit have in places a red colour. The purple tint, however, is rarely, if ever, met with in large masses. In one spot only, far removed from the limestone, have I ever observed it; this was in a shaly band occurring among Third-Grit sandstones, three miles north of Leeds, and five west of the limestone escarpment, on the turnpike road between High Moor Allerton and Hill Top, the nearest limestone outlier being distant three miles.

On the other hand, the purple colour of the Plumpton grit is by no means constant; thus a little north-east of Spofforth, on the road to North Deighton, the magnesian limestone in Newsome-Bridge Quarry is seen lying upon a very uneven surface of whitish grit with no trace of red or purple coloration; while but one-eighth of a mile distant, in St. Helen's Quarry, the grit is coarse and purple, and has lying upon its denuded surface a bed of red marl, at the thickest part five feet, and overlapped towards either end of the quarry by yellow limestone; the marl contains in one part a thin layer of apparently redeposited grit. I would here also observe that the lower part of the limestone, wherever it rests on grit, is apt very frequently to contain fragments of the latter or scattered quartz-pebbles.

As the result of my observations in general, I should infer that the frequent red and especially purple colour of beds immediately underlying the magnesian limestone is due in some way or other to the limestone covering, and its former extension further to the west. The coloration, I should presume, is chiefly due to the peroxidation of iron; and this, it seems to me, may take place in two ways—either by the action of carbonated water from the limestone above filtering through porous grits and sandstones, and converting the protoxides contained in them into sesquioxides, or by iron being brought from the overlying limestone, in the form of hydrate and carbonate, and redeposited in the rocks below.

Prof. Sedgwick says, in the same article before quoted, that "hydrate of iron appears to form the colouring-matter of many of the yellow beds of limestone, also of many of the beds of marl and sandstone," that "red oxide of iron, less generally diffused than the preceding, forms the greater part of the colouring-matter of the lower gypseous marls, also of many of the red beds in other parts of the series," that black oxide exists "in the form of black spots generally stellated and of dendritic impressions, rarely forms the colouring-matter of considerable masses," and that iron-pyrites is rare, but "probably exists in a state of minute subdivision in some earthy beds which are liable to effloresce." Probably the coloration of the underlying beds is due to both the peroxidation of iron already existing in the sandstones and shales, and to the introduction from above of colouring-matter, the former cause being very likely the most potent.

The non-colouring of the underlying beds in places is probably due to several reasons:—1st. Changes in mineral composition of the rocks to be coloured: thus some grits contain much red felspar, others but little; some sandstones and shales contain more mica and more iron oxides diffused through them than others. 2nd. Changes in the composition of the overlying limestone. 3rd. Differences in the porosity of the underlying rocks, some withstanding the infiltration of the carbonated water more than others.

With regard to this third point, one would naturally expect, as is the case, that permeable grits would be coloured to a greater thickness than impermeable shales; while such a rock as the calliard, mentioned as occurring near Barwick-in-Elmet, being so flinty and close-grained, might resist the percolation altogether; and accordingly it is found to be quite uncoloured, although its joints are lined with carbonate of lime. The upper parts of the coloured shales would likewise become marly by reason of the calcareous matter deposited within them.

I have thus been led to conclude that along the base of the magnesian limestone from Garforth, east of Leeds, to Knaresborough, striking across partly coal-measures and partly millstone-grit, there is no such thing as "Lower Red Sandstone" or "Rothliegende," but that any red or purple shales, sandstones, or grits occurring along this line are simply coal-measure or millstone-grit beds, as the case may be, which have been coloured through the agency of the overlying limestone.

Mr. Aveline has mentioned to me that the Coniston grits as they approach the carboniferous-limestone country of Ulverstone, where hæmatite is so abundant, are stained red, such a colour being nowhere else seen along their line of strike—but that in other parts, where the limestone, free from iron-ore, is not far removed from the grits, no coloration is observable. The clay-slates, however, do not exhibit any coloration when approaching the limestone hæmatite districts; this may be because they are less permeable. Again, Mr. Aveline tells me that the Silurians beneath the Old Red Sandstone near Kendal are also stained red.

Whether the red marls and sandstones beneath the magnesian limestone, all along the eastern edge of the Yorkshire coal-field, will turn out to be but coloured coal-measure beds, I leave others to prove; and I trust that Mr. Green, to whose valuable suggestions and help I am much indebted, will shortly be able more fully to corroborate and extend my present views on this subject.

May 26, 1869.

E. Story, Esq., M.A., F.L.S., 3 King Edward Terrace, Liverpool Road, Islington, N.; F. W. Harmer, Esq., of Heigham Grove, Norwich, and Henry J. Fotherby, M.D. Lond., M.R.C.S., Vice-President of the Hunterian Society, 40 Trinity Square, Tower Hill, E., were elected Fellows of the Society.

The following communications were read:—

1. *Notes on the* Geology *of the* Cape-York Peninsula, Australia. By Alexander Rattray, M.D. (Edin.), Surgeon, R.N.

(Communicated by the President.)

Perhaps no country in the world, Papua and the South Polar continent excepted, possesses a greater extent of unexplored territory than Australia. So much of its interior and of its northern or tropical portion (about one-fifth, or 60,000 square miles, according to Neumayer) is still a *terra incognita*, and so much of its natural history remains enveloped in mystery, that the following remarks with regard to one of its last-settled but still least-known parts may not be altogether devoid of interest.

Altogether apart from the attention long fixed on limited portions of this vast land, on account of its extensive and valuable mineral resources and the gold, copper, and coal found in its eastern and southern colonies, much curiosity of a more strictly scientific nature centres in it as a whole. And geologists are desirous of knowing the special and distinctive characteristics both of the settled districts and of the unoccupied and little or altogether unknown parts, in order to determine their relation to those of the adjacent islands of Tasmania, New Zealand, New Caledonia, and the Indian Archipelago (especially Papua, so close at hand), all known to possess a totally distinct fauna and flora, and of ascertaining whether these resemble or differ from those of other and perhaps better-known portions of the globe, especially their Antipodes in Europe, and particularly Great Britain, necessarily the chief standard of comparison to which English observers turn. Every item necessarily furthers this object; and hence these notes, which form an expansion of a paper read before the Philosophical (now Royal) Society of New South Wales in September 1865.

Australia has been called a land of anomalies; and its physical aspect fully corroborates the assertion. For, unlike other surfaces, whether insular or continental, instead of having a more or less median mountain-axis flanked by less lofty land, the ridge is here circumferential and closely borders the coast, so as to enclose an extensive, comparatively level, basin-like interior. Thus the *low*, and not the high land is central, as usually occurs. This well-marked margin is most developed along the west and east coasts, where the hills form a lofty continuous chain. The former runs at a distance of from 200 to 300 miles and upwards from the coast, and sometimes attains an altitude of more than 4000 feet above the sea-level. Its fellow, longer, loftier, and so pronounced as to form a well-marked back-bone to Eastern Australia, stretches from Cape Howe to Cape York, lying from 10 to 20 or 50 miles inland, and culminating in the Bellenden-Ker hills (5158 ft.) at the base of the Cape-York peninsula, but thence onward gradually decreasing in height, till close to Torres Strait they are seldom more than 300 feet above the sea-level.

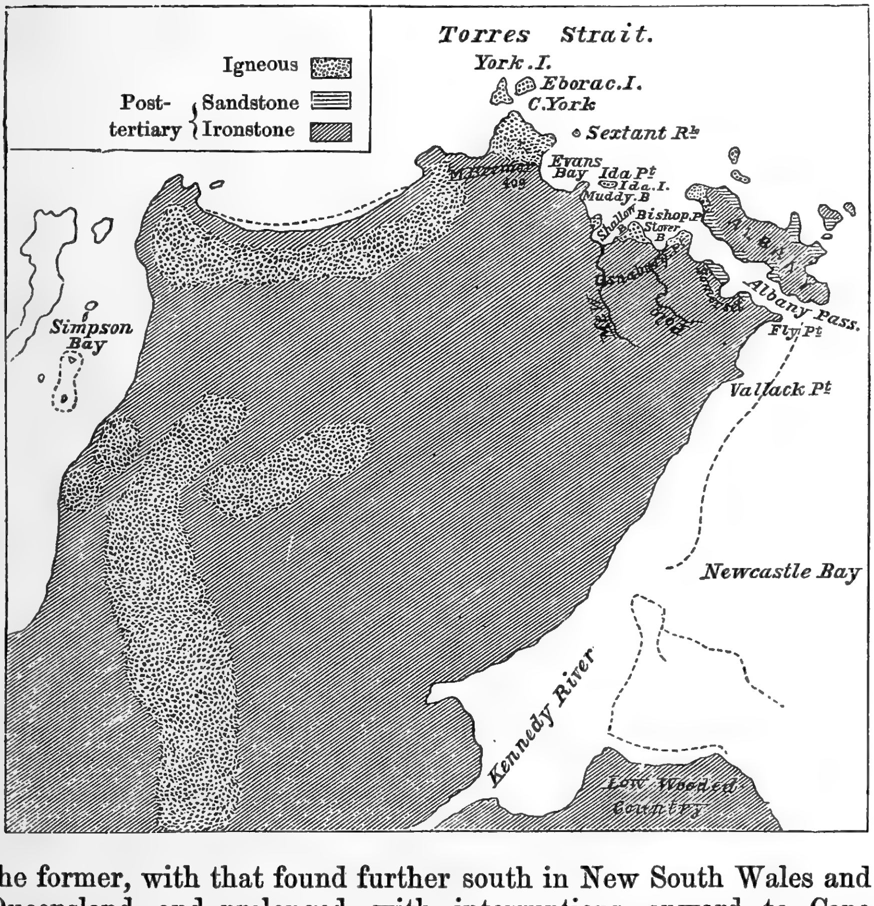
The Cape-York peninsula now alluded to, triangular in shape, is about 300 miles wide at its base, with a length thence northward to Cape York of more than 400 miles. Its mountain-range, a continuation of that further south, runs up along its eastern border, decreasing in height *pari passu* with the diminishing area of the land. On its east coast and within five miles of Cape York lies Albany island (see Map), three miles long, on an average half a mile broad, and separated from the mainland by the Albany Pass, a narrow gorge from 7 to 14 fathoms deep, and from half to three-quarters of a mile broad, through which the tide rushes with great force either way. Historically interesting from the fact that it was once the intended site of Somerset, but wisely abandoned, on the recommendation of the present Hydographer to the Admiralty, for a more eligible bay on the mainland opposite, Albany island is geologically interesting from the circumstance that it forms the principal centre from which we now take our survey of this part of Australia.

The range which thus forms a marked feature in the physical geography of the Cape-York peninsula, consists, as it does further south, of an axis of volcanic rock of varying constitution, but chiefly granite, porphyry, gneiss, felspar, and quartz. Thus the vicinity of Port Denison, Cape Melville, and the coast about Cape Direction, and Weymouth and Fair Capes are granitic, and the pointed end of the peninsula porphyritic, while some of the offlying islands, outliers, so to speak, of the main range, likewise differ: *e. g.* Dunk Island, the Family group, Lizard Island, the Forbes and Hardy Islands are all granitic, the Franklands gneissic, and Sunday Island flesh-coloured compact felspar. The islands of Torres Strait may be regarded as an interrupted portion of this range, which is doubtless continued into New Guinea. Of these, Turtle-back, Mount-Ernest, Poll, Banks, Burke, Mount-Adolphus, and the Farewell Islands are all granitic. Towards Cape York this igneous axis has undergone less elevation; still the underlying crystalline rock occasionally appears above the surface as intruded masses of porphyry, surrounded and overlain by more recent formations. For example, at the north end of Albany Island it forms a large boss; at Osnaburg, Bishop, Ida, and Evans Points, and at Cape York we find it in bluffs and promontories; and at Ida, York, and Eborac Islands &c., in more elevated masses or isolated hills which culminate in

Mount Bremer (409 ft., see Map). In all, the porphyry presents nearly the same lithological characters, and consists of a matrix of felspar enclosing numerous crystals of yellowish quartz. Near Cape York it is laminated.

Resting on the eastern and western flanks of this igneous axis are thick and extensive strata of sandstone, doubtless continuous, like

Fig. 1.—*Geological Map of Cape York.*



the former, with that found further south in New South Wales and Queensland, and prolonged, with interruptions, onward to Cape Bathurst, where it forms a bold cliff overhanging the sea, as well as the main mass of the adjacent Flinders group. Here, however, it becomes lost, to reappear, it is alleged, in Papua, resting on the flanks of the igneous axis of that island, itself a continuation of that of Eastern Australia across the intervening strait which is only 90 miles wide. The nature of this sedimentary rock has long been disputed, the Rev. W. B. Clarke and his followers maintaining that it is Carboniferous (Palæozoic), while Professor McCoy and his adherents believe it to be more recent and Oolitic (Secondary).

As yet no auriferous quartz or gold-bearing "gullies" or "creeks" have been found in or near the mountain-axis of the Cape-York peninsula, like those of the richly productive regions in Victoria, New South Wales, and Northern Queensland, nor copper-mines like those of Burra-Burra and the Peak Downs, nor in its sandstones valuable and extensive coal-beds like those of the Illawarra and Hunter-River districts. But no reason is apparent why all these, and perhaps other minerals, should not exist in this part of the range as in its continuation further south. Coal has been found as far north as Port Denison (lat. 20° S.), and gold and copper at the Peak Downs (lat. 23° S.), the former 200 and the latter 350 miles from the base of the peninsula, and they may extend well on towards Cape York. We must remember that this by no means insignificant portion of Australia has been very imperfectly explored, and, what is perhaps of greater moment as far as useful discoveries go, is very thinly peopled. True, Kennedy in 1848 advanced along the coast to the eastward of the main range nearly as far as Cape York, which goal the Jardines actually reached in December 1864, by traversing the more passable region to the west of the range; while Leichardt (1845) and A. Gregory made a slight détour into the western part of its broad base, on their westward way; but these explorers, for various reasons, had little time or opportunity for prospecting. The existence of mineral treasures is most frequently discovered by private enterprise, and often by the unscientific though practical hands of settlers. As yet, however, only a trivial part of the south-west region is occupied, and that scantily; while one rudimentary township of sixteen persons exists near Cape York. Thus neither the north nor the south is capable of furnishing men or money to investigate the extensive intermediate district, the barren character and treacherous natives of which are obstacles sufficient to deter all but the most resolute and well provided from attempts of this nature, and from engaging in labour the results of which are necessarily very uncertain.

The surface rock in the neighbourhood of Cape York, including Albany island and the vicinity of Somerset, consists of ironstone varying from a comparatively light friable clay-carbonate to a heavier dense ferruginous conglomerate, usually vesicular, honeycombed and channelled on its exposed surface from weathering. Its density and hardness differ with the varying proportion of iron. Sometimes it is nodular, very hard, highly metalliferous and magnetic. Under atmospheric and other physical agencies these nodules separate from the clayey matrix, and lie scattered plentifully over the surface in the form of rounded or oval pebbles, and small boulders having a dark metallic lustre. On the other hand the soil which is the principal result of this disintegration is fine-grained, dirty-red, and sometimes unmodified, but oftener mixed with coarse quartzose sand and vegetable mould, but in all cases scanty and poor. This circumstance, conjoined with the protracted droughts of the dry S.E. monsoon, lasting from eight to ten months, materially influences the character of the vegetation, which is stunted and undergrown, and seldom possesses the luxuriance we might expect within $10\frac{1}{2}°$ of the physical and 8° of the thermal equator, except along the banks of the Polo, Mew, and similar paltry streams and creeks of the neighbourhood, where the soil is more alluvial and the vegetation more tropical. But even there it contrasts strongly with its vigour and abundance further south, where the soil is formed of the detritus of primary, metamorphic and sandstone rocks and shales, the water-supply more copious, and both the physical geography, geology, and climate more favourable for growth. The diminutive ants which abound here appear to prefer this ferruginous soil, which they convert into a hard sun-dried clay, to construct their peculiar pinnacled ant-hills, often 12 to 15 feet high, which form a conspicuous feature on the hillsides and landscapes of the vicinity of Somerset. It would be interesting to know whether or not this formation also extends, like the two former, across Torres Strait into New Guinea. Certainly a considerable patch of the southern part of that island immediately opposite Cape York, is a blank in our most trustworthy geological maps, which may yet be filled up by the formations now named. The overland expedition of the Jardines has proved that this rock is found as far south, on the west side of the mountain-range, as the Mitchell River; and it probably extends westward to the Gulf of Carpentaria, while on the east side of the range it certainly exists as far as Weymouth Bay. According to the Rev. W. B. Clarke, of Sydney, this rock "is post-tertiary, as it contains no gold; otherwise it most highly resembles the common ironstone in the auriferous rocks of New South Wales." A careful assay of an average specimen made for me by his instigation at the Royal Mint of Sydney, in March 1865, showed that the ore contained 39·69 per cent. of iron, but neither gold nor silver. Though capable of yielding a fair per-centage of metal, the absence of coal in the vicinity, the high price of labour, great distance, and cost of carriage of the former to and of the smelted iron from the settlement, will, however, long and perhaps always render this ore practically unavailable.

Lying between the volcanic rock beneath and the superimposed Posttertiary ironstone, we find a more local and limited deposit in the form of a coarse quartzose sandstone, having a wavy stratification, and composed of attrited fragments of quartz varying from ordinary sand particles to the size of a hazel-nut, imbedded in a light clayey matrix, very friable and unfit for building when weathered. Of this, several of the bold cliffs of Albany island and the opposite mainland consist; and these are so directly opposed, while the bluffs and bays on either side would dovetail so accurately if brought together, that we may fairly conjecture that they were once continuous, before the production of the huge cleft which now forms the Albany pass, or the upheaval of the crystalline rock beneath, which was doubtless the cause of this. A similar quartzose sandstone was also found by the Jardines at various places along their route, and there as here in connexion with ironstone. It would be interesting to know whether a like formation exists in the adjacent part of New Guinea. No fossils have yet been detected in this rock. At the north end of Albany island, where a boss of porphyry protrudes and displaces the overlying sandstone and ironstone, fine examples of chertified clay-ironstone and quartzite may be seen at their point of contact.

McCoy alleges the existence of cretaceous rocks about the upper part of the Flinders, not far from the western part of the base of the peninsula, which is interesting in connexion with their possible presence on the same side of the eastern backbone at its southern end near Melbourne and the great Australian bight, and also in Western Australia, doubtless in relation to that coast-range. No grooving or scratching of rocks, boulder-deposts, or other evidence of glacial action has anywhere been observed along this north-east coast, or at the pointed northern extremity of the Cape-York peninsula.

Thus Eastern Australia has its Posttertiary as well as its Tertiary, Secondary, Palæozoic, and Azoic formations, in addition to the ordinary igneous basis on which they rest; and their presence tends to confirm the opinion expressed by the Rev. W. B. Clarke as to the parallelism and agreement (with a few exceptions, which perhaps future discovery will remove) between these systems of the Australasian province (in which he includes Australia proper, with the islands of Tasmania to the southward, New Zealand to the south-east, New Caledonia to the east, and Papua to the northward) and those of its antipodes, and to show that it is highly probable that the same geological formations exist here as in Europe, and that the same great laws were concerned in developing them. Little more can be done than to make dubious conjectures as to the geology of Papua; for even its coast remains unexplored, and our knowledge, if it may be so called, is merely subjective and based chiefly on evidence derived from stray facts and comparison of its physical features with those of other, and particularly neighbouring, islands.

Though a non-volcanic country, with one trivial exception (Mount Wingen, in the Liverpool range, 120 miles north from Sydney), Australia is occasionally subject to earthquake-shocks or earthwaves, doubtless propagated from neighbouring true volcanic centres, e. g. New Zealand to the south-east and New Caledonia and the islands of the Indian Archipelago to the east and north, and sometimes perhaps from more distant regions. A slight shock was evident at Cape York in March, 1865, and a stronger one during December, 1866. Equally interesting is the evidence that the north-east, if not the whole of the east coast of Australia, is slowly rising, to be found in the gradual shoaling of the channel between Hinchinbrook Island and the mainland (lat. $18\frac{1}{2}°$ S.), which is due, to all appearance, neither to silting up nor to the growth of coral—in the presence of water-worn caves in the sandstone cliffs of Albany island and those of the mainland opposite, now well above high-water mark—and in the existence along many parts of the coast, especially towards the northern end of the peninsula, of extensive tracts of level country now covered with sand-dunes bearing a scanty vegetation stretching inland and on either side to the base of lofty hills now ten, fifteen, or twenty miles off, but which had once closely bordered the sea, the whole looking as if they had once been under water. Corroborative evidence of this will probably be found in the shoaling of the inner barrier-reef route and the numerous openings through it, as well as the reef itself, which will one day be out of water, like Raine and other islands, when the region is resurveyed many years hence.

The great barrier-reef of Australia is evidently formed by the growth of coral on the summit of a lengthy submarine hilly ridge, which runs at a distance of from fifty miles, at its southern extremity, midway down the east coast (lat. 22° S.), to ten miles, near Cape York, leaving a long shallow valley between it and the mainland, now converted into the navigable passage named the inner barrier-reef route, the depth of which varies only from 10 to 50 fathoms; whereas the outer aspect of the reef shelves steeply like a wall, no bottom being found only a short distance off at 100 to 250 fathoms, where the clear and dark-green waters and long ocean-swell form a marked contrast to the light green of the tranquil but turbid inner passage. The reef may be said to consist of the *reef proper* and *islands*. The former, which constitutes the main mass of this lengthy coral tract, consists of a series of broad flat irregular more or less rounded or oval ledges of coral in full activity, covering the tops of the submarine hills, occasionally dry but usually close to the surface at low water, and sometimes many miles long, their position at high water being marked by a line of surf or the light green hue of the shallow water over them. On the other hand the islands are of three different kinds, viz. igneous, coral islands, and sand-banks.

1st. Occasionally the higher peaks of this barrier ridge project well out of the water, as in the Forbes, Hardy, Cockburn, Murray, and other islands, which are in a line with and really form part of the range—and Sunday, Lizard, Eagle, the Franklands, Dunk, and others, which lie between it and the coast. Round these projecting masses of crystalline rock we find the usual fringing reef of coral, of species identical with those growing on the summits of the ridge which forms the barrier proper. But on their sides we find no evidence of coral growth, proving that though they must have, at least, once been submerged, like the adjacent continent, this must have been when no coral grew in the Australian seas.

2nd. Here and there, however, we meet with islands of another class, of which Raine, Cairncross, the Howick group, &c. may be taken as types, a few of which, like the first named, form part of the reef, but the majority, like the last of the three, are met with in clusters, between it and the mainland. Raine island, taken as an example, which possesses its own special and active fringing reef, is low, flat, about one-third of a mile long and a quarter of a mile broad; it rises about 10 feet above high water, and consists of hard compact brecciated coral conglomerate, with a shelving beach of coarse coralline and shelly sand, and a scanty superstratum composed of the coral débris sparingly mixed with vegetable matter, and a thin layer of guano deposited by the numerous turtle and flocks of terns, gannets, and other aquatic birds that, like the former, make this their headquarters and favourite breeding-place. The whole constitutes a soil capable of supporting a scanty vegetation of weeds, coarse grass and creepers, but sometimes, as at Cairncross, the Howicks, Pipers, and many others, a dense scrub and well-grown Mangroves, Casuarinæ, Pandani, Pisoniæ, and other trees common along this coast. Of this organic rock the beacon on Raine Island was built eighteen or nineteen years ago; and the durability of the material is shown by the fact that the structure has hitherto undergone no decay from weathering. It doubtless tops some crystalline formation on which it has been slowly reared. Still it is evident that, though now permanently out of, it must have been formed well under water, and have reached the surface at low water with the zoophytes which built it in full activity, when the greater part of the long reef now in full activity at the sea-level at ebb, and of which it forms only a fractional part, was still many feet below. And now, when the latter has reached close to the surface at low water, the former projects 20 feet into the air; but denuded by weathering of its soft and brittle exterior, with its dense solid interior laid bare, and its living many-hued branching madrepores replaced by less gaudy forms of vegetable life.

3rd. Between the active coral-reef still under water; and the extinct ones now well raised above it, like Raine Island, we meet with many intermediate forms, occasionally as islets, which consist of a sand-bank just showing above the surface, and either still unclad with vegetation or having a few sprouts of mangrove, the hardiest of trees, and usually the first to find a footing in the coarse coral débris, little capable, to all appearance, of sustaining life of any sort; while others show greater elevation, and both a more extensive and better-clad area. In short, we find islands of this class in many different stages of upward progress, sometimes forming part of the reef, but more usually lying between it and the mainland, when they occasionally interfere materially with the navigation of the inner passage from being difficult to detect in the bright glare of the sun until the vessel is too close to them to be consistent with her safety.

Besides the above, other indications of the gradual rising of this coast may not improbably be found on a more careful survey of the land than could be afforded during the rapid passages of H.M.S. 'Salamander' up and down, when landing was effected only occasionally and for periods too brief to be of much avail for geological purposes. The elevation of Eastern Australia is going on very slowly, because the forces which are at least connected in some way with, if they do not actually induce it, are not in the island itself, but distant, and centred either in New Zealand, New Caledonia, the Indian archipelago, or the still more remote volcanic districts of the South Pacific. These facts, taken in connexion with the recent discovery by Bickmore, an American geologist, that the eastern coast of Asia, and especially China and Japan, is also rising, and doubtless more rapidly, like the opposite coast of South America, while the bed of the South Pacific is slowly subsiding, cannot fail to be interesting to scientific men, whether or not they accept Prévost's and Dana's theory in explanation, viz. that it is due to the greater contraction of the earth's crust beneath the ocean, which causes it to sink, while the land on either side becomes elevated by lateral pressure, and by both processes necessarily drained.

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2. *On the* FORMATION *of the* CHESIL BANK, DORSET. By H. W. BRISTOW, Esq., F.R.S., F.G.S., and WM. WHITAKER, Esq., B.A., F.G.S.

[This paper has been withdrawn by the permission of the Council.]

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3. *On a* RAISED BEACH *at* PORTLAND BILL, DORSET. By W. WHITAKER, Esq., B.A., F.G.S.

[This paper has been withdrawn by the permission of the Council.]

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4. *On the Occurrence of* TEREBRATULA DIPHYA *in the* ALPS *of the* CANTON DE VAUD. By E. TAWNEY, Esq., F.G.S., Assoc. R. Sch. Mines. *With a Note by* THOMAS DAVIDSON, Esq., F.R.S., F.G.S.

IN answer to certain statements of Prof. Hébert as to the probability of the non-occurrence of *Terebratula diphya* in the Jurassic Series (Bulletin Soc. Géol. de France, vol. xxiii. p. 530, 1866), it may be well to put on record the following discovery of this species in strata in the Alps of the Canton de Vaud, which belong indubitably to the Oxfordian series. This is, I believe, the first time that this species has been found in Jurassic beds in the Canton.

In the summer of 1867, when exploring the geology of the valley of the Sarine, near Château d'Oex (Canton de Vaud), I came upon this fossil in a block of Oxfordian limestone, among the "éboulis" around the chalets of Paray Charbon: these blocks, which are nearly all Oxfordian, have fallen from the ridge of the Vanil Noir. This range, from Mont Cray to Dent de Branleire, which forms here the boundary between the Cantons de Vaud and Fribourg, is formed by an arch of Bajocian (Inf. Ool.) dark grey limestones and shales, surmounted by the Oxfordian series at the N.E. end (Dent de Branleire, &c.); but the vault rises higher where the chain becomes lower, so that at the S.W. end the Oxfordian is thrown off only at the sides, and is quite cut away from the top, the summit of Mont Cray being Bajocian.

As our locality is about the middle of the range, the Oxfordian is seen at some height in the precipices above the chalet.

The Bajocian, which contains *Zoophycos scoparius* (Heer) abundantly here, and *Amm. Humphriesianus*, consists of dark-coloured limestones and shales, and is in strong contrast to the blocks of Oxfordian limestone which lie upon it; the latter here is a limestone of lithographic texture and conchoidal fracture. It could not be mistaken for the Neocomian, being thicker-bedded and full of irregular branching chert concretions, which sufficiently distinguish it, and, what is more important, the Neocomian does not occur within several miles. It is almost unnecessary to add that the blocks are not transported; they are all Bajocian or Oxfordian, and lie immediately under the escarpments from which they are derived.

The accompanying fossils are not numerous; I only found *Belemnites hastatus* and other Belemnites.

We have thus a clear case of the occurrence of this remarkable form of Brachiopod in the Oxfordian limestones of the Alps.

I have wished to record this, because the high authority of Prof. Hébert has been lent to the view * that *Ter. diphya* of the Oxfordian is the same species as *Ter. diphyoides* of the Neocomian, and, further, that those authors are mistaken † who have cited *Ter. diphya* from Oxfordian beds in France. It is against the latter reasoning that we may here protest. I in no way wish to throw doubt on Prof. Hébert's criticisms on M. Lory's work on the beds at Porte-de-France (Grenoble), a profound palæontological one, and particularly useful among the Neocomian and Oxfordian beds, which in the Alps so often not only simulate each other lithologically, but whose fossils, in a fragmentary condition, are sometimes hard to distinguish.

But, as he himself admits, in counting all the beds with *Ter. diphya* at the Porte-de-France as Neocomian, he leaves unexplained the presence of *Aptychus lamellosus* and *A. lævis* (Oxfordian species) and the breccia with Corallian fossils. But at any rate it is not shown, because *Ter. diphya* does not occur in the Oxfordian at Grenoble, that it does not occur in that formation elsewhere.

I may remark that my specimen of *Ter. diphya* differs considerably from specimens of *Ter. diphyoides* which I have found in the Neocomian of Meruet (Mont Argentine, Vaud), and from specimens in the Museum of Lausanne from Chatel St. Denis (Vaud); but without a series of specimens it would be impossible to assert that they are distinct species. Prof. Hébert has not apparently had Oxfordian specimens to compare with the Neocomian ones, as he does not admit that in France *Ter. diphya* could have been found in Oxfordian beds ‡ with Oxfordian Ammonites.

May we not in this case revert to the opinions of the author of the Paléontologie Française (especially as Prof. Hébert's arguments almost seem to exclude one another), and hold that different species are found in the Jurassic and Cretaceous periods.

At all events we have shown that *Ter. diphya* does occur in the Jurassic period.

Note by Mr. Davidson.

In connexion with Mr. E. Tawney's interesting communication, I would mention that I have recently had occasion to converse with

* *Vide* Archives des Sciences Naturelles, p. 303, Aug. 1866. Geneva.

† Bull. Soc. Géol. de France, ser. ii. vol. xxiii. p. 529.

‡ *Ibid.* vol. xxiii. p. 581.

MM. Coquand, Hébert, Pictet, de Verneuil, E. Renevier, and others, as to the real or supposed age of the rock which, at the Porte-de-France, contains the *Terebratula viator* (*diphya*), Pictet. I may also observe that, with the exception of MM. Hébert and Lory, the geologists above named seem to consider the deposit in question referable either to the Jurassic period or, rather, to the stage termed Tithonian, which some geologists consider to be intermediate in age between the Neocomian and Jurassic, while M. Hébert still correlates it with the lowest stage of the Neocomian, his "calcaire à *Ammonites macilentus*." The difference in opinion seems, however, to be gradually disappearing, and I believe that the limestone of the Porte-de-France will finally be left where M. Hébert has placed it *.

When at Geneva (on the 16th of February), M. Pictet showed me his interesting series of Diphyoid *Terebratulæ*, assembled from various localities, and at the same time pointed out the differences, with which I was already acquainted, and which appeared to him to distinguish the Cretaceous from the Jurassic (?) form.

Thus, in the shell from the Porte-de-France (*Ter. viator*, Pictet) there exists in the larger or ventral valve a regularly subparallel fold, commencing at the extremity of the truncated beak and extending to the central portion of the anterior frontal margin, and that whether the deviating lateral halves of the valves remain permanently apart, or become again conjoined in front so as to leave a circular hole in the middle of the shell. In the cretaceous *T. diphyoides*, on the contrary, the same fold has a longitudinal or concave depression along its middle. In the smaller or dorsal valve there exists in *T. viator* a depression or concave sinus, commencing at the umbonal beak and extending to the frontal margin, while in *T. diphyoides* the same sinus has along its middle a narrow rounded elevation. There are also several other minor differences, though I must confess that, apart from these peculiarities, there exists a strong resemblance between *T. viator* and *T. diphyoides*; consequently it is necessary, in order to be able to discriminate between the two species, to attend to the differences above specified. In his elaborate memoir on the "Térébratules du groupe de la *T. diphya*, 1867," M. Pictet furnishes us with a numerous series of figures in which all the principal modifications in form are faithfully represented.

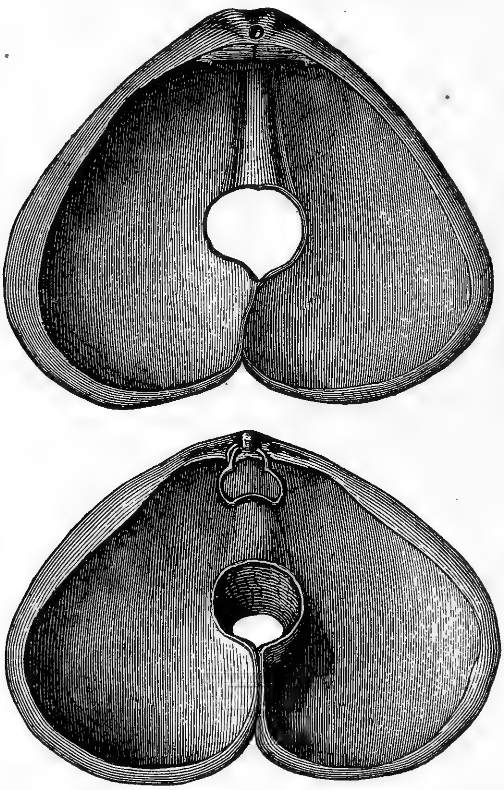
In 1830 Link proposed to distinguish the Diphyoid shells by the generic denomination of *Pygope*, which view was afterwards advocated by Prof. King †; but all the palæontologists who have subsequently written on the subject have preferred leaving these shells in the genus *Terebratula*. I had likewise, in 1848, informed Prof. King that the loop in *T. diphyoides* (and no doubt in *T. diphya* and *viator*) was short, and much resembling in shape and character what we find in *T. vitrea*, *T. carnea*, etc. And since the interior

* See "Notes on Continental Geology" in the April, May, June, and July numbers of the Geological Magazine for 1869.

† A monograph of the Permian Fossils of Great Britain.

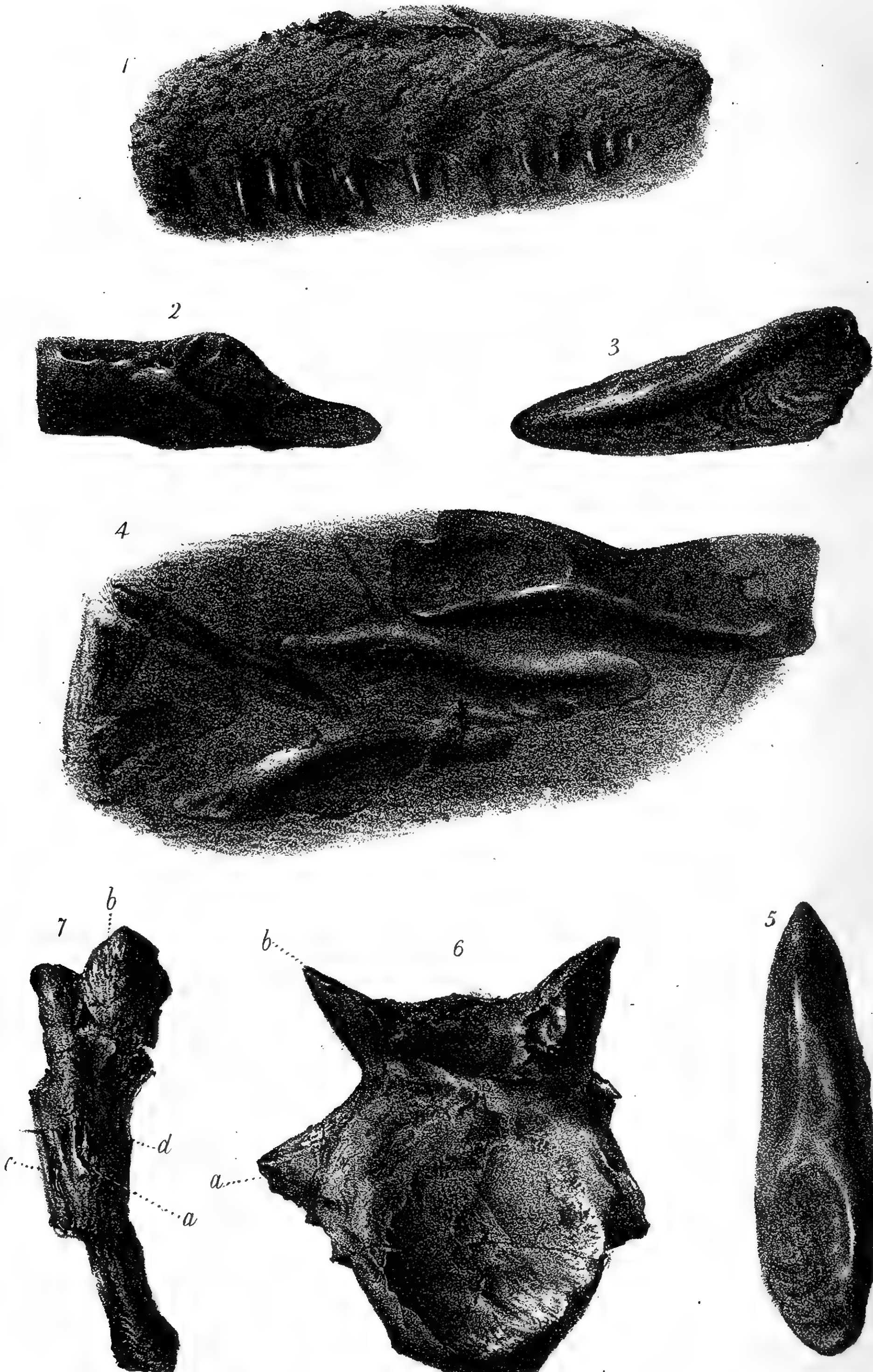
was unknown to M. Pictet at the time he published his work, I here append the drawings I made in 1848 from specimens formerly in the possession of the late M. Bouchard, which had been sent to

Fig. 1.—*Terebratula diphyoides.*



him by M. Malbos, from the compact limestone of Berrias (Ardèche). I never could see the necessity of burdening nomenclature by the adoption of a distinct generic denomination for these shells; and we should not be zoologically warranted in supposing that because the mantle or lateral portions of the valves have been more or less prolonged, we have therefore valid grounds for the creation of a new genus, any more than we are warranted in separating *Orthis biloba*, Linn., from the Genus *Orthis* because the lateral portions of the valves are more or less prolonged in a similar manner to what we find in the deviating lobes of the valves in certain specimens of *T. diphyoides*, *T. viator*, etc.

It is very interesting to know that Mr. E. Tawney has discovered a Diphyoid Terebratula in a block of "Oxfordian age" in the Canton de Vaud, and it is most probable that the shell is referable to *T. viator*; but in that case it would be very necessary that the true age of the block in question should be accurately determined, so as to feel certain that it also might not pertain to the age of the limestone of the Porte-de-France. Nor must it be forgotten that M. Alphonse Favre found a similar specimen at Voisons, near Geneva, which is described and figured in Pictet's work above named. In Switzer-



E. FIELDING LITH. M & N HANHART IMP.

PHOLIDERPETON.

land we also meet with the true *T. diphyoides* in rocks of Cretaceous age; a description and figures of it will be found in W. A. Ooster's 'Synopsis des Brachiopodes des Alpes Suisses,' p. 19, pl. v. figs. 1–4, 1863. I have seen the specimen of *T. viator*, which M. Coquand assures me he found in Africa in rocks of Jurassic age (?), and likewise others obtained by MM. de Verneuil and Favre in Spain. The Diphyiod shells were at one time considered to be rare fossils; but within the last few years they have been discovered in many localities, although never hitherto in Great Britain.

Discussion.

Mr. J. W. Judd thought that the break usually existing between the Neocomian and Jurassic beds indicated a long interval of time, and that certain deposits in the Carpathians and elsewhere had been rightly referred to this intermediate period. Possibly, therefore, the Diphyoid *Terebratulæ*, commencing in the Jurassic, lived on through the Tithonian into the Neocomian period.

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5. *On a new* Labyrinthodont *from* Bradford.

By T. H. Huxley, LL.D. F.R.S., President of the Geological Society.

(Plate XI.)

The specimen which Mr. Miall has been so good as to send for my examination is without doubt a Labyrinthodont Amphibian. This is proved by the character of the vertebræ, of the ribs, and of the ventral armour. But the state of the fossil is such that it is not easy to discover points in which it can be strictly compared with those forms of Labyrinthodonts which are already known.

For example, nothing remains of the skull but some fragments of the upper and lower jaws. The piece of bone which represents the right upper jaw is 7 inches long, and has, like a fragment of the left upper jaw which lies below it, a pitted sculpture. A part of the right ramus of the mandible, with its symphysial end entire, is about 6 inches long, and about half an inch deep at the symphysis. Both upper and lower jaws bear close-set, even-sized teeth, nearly circular in section and somewhat recurved at their apices, which are rather obtusely pointed. Parallel longitudinal folds are indicated upon the basal halves of some of these teeth, the largest of which is not more than 0·5 in. long, by 0·15 in. thick at the base (Pl. XI. fig. 1). An impression of a conical acutely pointed tooth, much larger than any of these (seeing that it must have had a length of nearly an inch when it was entire), is seen upon the matrix, 2 inches below the ramus of the mandible.

These features of the fossil prove sufficiently that it is not *Anthracosaurus*, but leave open the question of its identity with other Coal-measure Labyrinthodonts, and especially with *Pholidogaster*, the only fragments of the teeth which are preserved, in the latter genus, being not unlike those of the present specimen.

Impressions of some four or five and twenty vertebræ are discernible upon the slab of shale from Bradford. In all, only the centra are discernible, without any indication of arches or processes. The centra are discoidal, concave on each face, and incline to be somewhat polygonal in contour. They singularly resemble the vertebræ of *Anthracosaurus*, and, like them, remind one strongly of *Ichthyosaurus*. The concave face of the largest is 1·4 in. in diameter. In no case can the antero-posterior dimension be made out with accuracy; but it seems not to have exceeded one-third or one-fourth of the transverse diameter. A detached vertebra which, I am informed by Mr. Miall, undoubtedly belongs to the fossil, presents a centrum which is quite similar to those scattered about on the slab, together with well-developed articular processes (*b*, figs. 6 & 7) and remains of transverse processes (*a*, figs. 6 & 7). The vertebra is much broken, and may have undergone some slight distortion; but its proportions cannot have been very different from those displayed in figs. 6 & 7, and these are very different from those of the vertebræ of *Pholidogaster*.

The ribs are strong and curved; the largest measures not less than 7 inches along the chord of its arc, while its shaft is 0·3 in. thick. The shortest rib is about 3 inches long, and tapers to a point at its distal end. The proximal ends of the ribs are expanded and divided into two articular facets. No such strong ribs as these are visible in the only known specimen of *Pholidogaster*; but they are very like the ribs of *Anthracosaurus*.

The ventral armour of the Bradford fossil consists of scutes (figs. 2, 3, 4, 5), the largest of which are about 2 inches in long diameter, and half an inch across. One end of each scute is rather narrower than the other, and the outer surface of each is traversed obliquely by a convex ridge, which passes from the small to the large end of the plate, and thus divides it into two unequal facets. The facets are occasionally rugose, but are not sculptured; the convex ridge dividing them is smooth. The plates seem to have overlapped one another in such a way as to expose little more than the surface of the oblique ridges; but the precise manner of their arrangement is nowhere shown with clearness in the specimen.

What appear to be remains of the thoracic plates and of the shoulder-girdle are visible, but there are no certain traces of limbs.

I cannot identify this interesting fossil with any generic form at present known. It resembles *Pholidogaster* more than any genus with which I am acquainted; but it differs therefrom altogether in the form of its vertebral centra, and in the details of its ventral armour.

On the whole, I think it will be best to recognize it as a new generic and specific form, for which I propose the name of *Pholiderpeton scutigerum*.

Note on the Locality *of the* Fossil *above described.*

By Louis C. Miall, Esq.

[Abridged.]

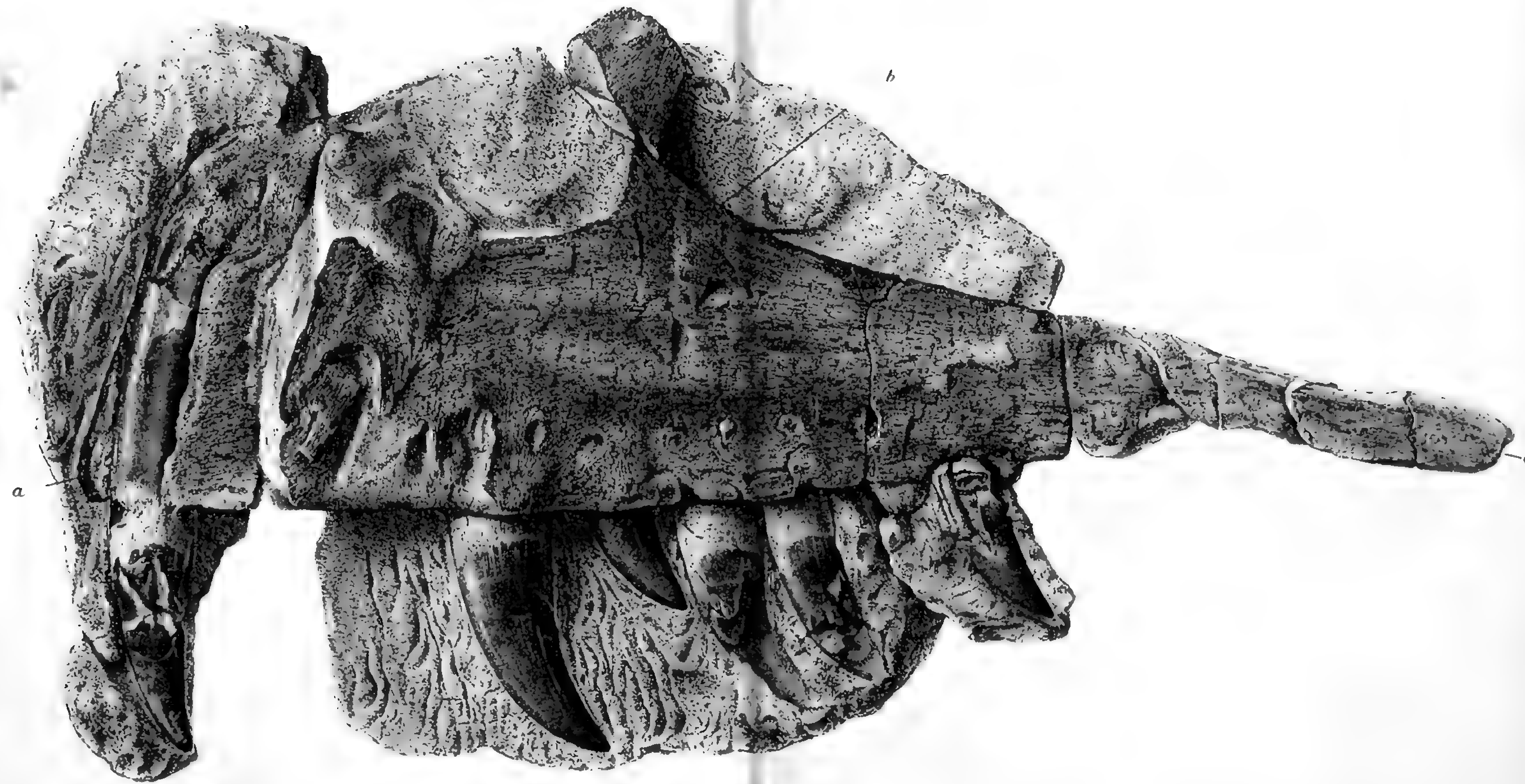
Fragments of the fossil above described were found last summer in the roof of the Black-Bed or Royd's Coal, at Toftshaw, near Bradford.

G.H Ford

UPPER JAW

W West imp.

MEGALOSAURUS.



G. H. Ford

W West imp

UPPER JAW OF MEGALOSAURUS.

Much difficulty was experienced in extricating the remains uninjured, for the coal beneath had yet to be worked. The greater portion was ultimately removed in a fair state of preservation, owing to the persevering attention of William Firth, a miner whose zeal was stimulated by some knowledge of geology and in particular of coal fossils.

The shale which forms the roof of the Black-Bed Coal has long been known to collectors as a repository of interesting and well-preserved fish-remains.

The Black-Bed Coal is in the middle division of the Yorkshire Coal-field, lying about 40 yards above the Better-Bed Coal, and separated by about 220 yards from the Halifax Coals, which are the lowest workable seams. The exact horizon of important fossils is, perhaps, worth noting, though within the Coal-measures no true vertical limits of species are known to exist.

Judging from a cursory survey of several public and private collections, I am inclined to think that the remains of various interesting Carboniferous Batrachians are still unrecognized as such, and taken by their possessors for parts of fishes. When we are in a position to make a correct estimate, it will probably be found that the Batrachia of the Coal-measures are not only specifically numerous but individually abundant.

EXPLANATION OF PLATE XI.

(*All the figures are of the natural size.*)

Fig. 1. Part of the upper jaw with teeth of *Pholiderpeton scutigerum.*
Figs. 2, 3, 4, 5. Scutes from various parts of the body.
Fig. 6. Front view, and Fig. 7, side view, of a detached vertebra: *a*, remains of the transverse process; *b*, the præzygapophyses; *c*, the posterior face of the centrum, the inferior moiety of which is broken away.

Discussion.

Mr. Salter observed that, of both plants and mollusks, it appeared to him that there were some which were eminently characteristic of different horizons in the Coal-measures, and which were to be traced over large areas. It was possible that the same might prove to be true with regard to vertebrate animals.

Dr. Duncan called attention to the conditions of life necessary for such an animal, which could not have been in accordance with the commonly received views of the character of the Carboniferous period.

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6. *On the* Upper Jaw *of* Megalosaurus. By T. H. Huxley, LL.D., F.R.S., President of the Geological Society.

(Plate XII.)

As all who have paid attention to the *Dinosauria* are aware, our knowledge of the structure of the skull in these extinct reptiles is very defective. This is particularly true of *Megalosaurus,* of which, up to the present time, only a portion of the lower jaw has been known. I am therefore very glad to be enabled, by the kindness of

Mr. Abbay, the possessor of the magnificent left upper jaw of *Megalosaurus* now exhibited, to make a definite addition to our means of reconstructing that monstrous Saurian.

The jaw (Plate XII.) is 17·75 inches in length. At its anterior end it measures 4·3 inches in a direction perpendicular to its length. For about an inch and a half from the anterior edge (*a*), which is entire and shows the natural face of this part of the bone, the upper, or nasal, margin is nearly parallel with the lower, or alveolar, margin; but further back the bone was evidently produced into a great ascending process (*b*), which divided the nasal from the orbital region. The base of this process is fully four and a half inches long. Its anterior margin slopes rapidly backwards and upwards, and seems to have been nearly straight; while the posterior margin is concave backwards and presents a natural edge, which formed the front boundary of the orbit. The distance in a vertical line from the alveolar margin to the broken upper extremity of the ascending process is 6·75 inches. Behind the ascending process, the vertical diameter of the jaw diminishes, until, at 10 inches from its anterior end, its vertical diameter does not exceed 2·6 in. Behind this point the jaw seems to diminish to a mere bar of bone, not an inch deep at its posterior extremity. But the impression on the lower part of the matrix which occupies the cavity of the orbit shows that the natural edge of the jaw in this region has been somewhat broken away, and that, if it were entire, the depth of the jaw, at 12 inches from the anterior end, would be 2·1 inches, instead of only 1·7 inch as it appears to be. At this place, namely 12 inches from the anterior end, the jaw is transversely fractured; and though the slender prolongation adjusts quite accurately to the broken surface and evidently fitted on, it has, as evidently, lost a good deal along its upper or orbital margin.

Again, the general character of the slender posterior termination of the jaw (*c*) is such that one would be inclined to think it could not have been directly connected with any other bone; but the part is so much injured that it is not safe to draw any very positive conclusions about the matter. The jaw is traversed by a vertical fracture 2·4 inches from its anterior end. The fracture passes from the alveolar margin to the nasal margin at the commencement of the ascending process. I was at first disposed to think that the fracture coincided with a suture between the præmaxilla and the maxilla; but closer examination does not confirm this supposition, the fracture appearing to be altogether artificial. Hence it would appear either that the præmaxilla and maxilla were so completely ankylosed that all trace of their primitive separation is lost, or that the præmaxilla has become detached from the maxilla, or that the jaw is simply the præmaxilla—a possibility which must not be lost sight of in view of the resemblances between *Dinosauria* and Birds.

The teeth which remain in their places in the jaw, and are visible from the outer side, are six in number. Five of these, the first, second, third, fourth, and fifth, appear to be completely in place; the third is emerging. On the inner face of the jaw the crown of a sixth tooth, in course of development, lies on the inner side of the base of the fifth.

The first tooth is laid bare by the breaking away of the substance of the jaw through its whole length. It measures 6·4 inches in length, 2·6 inches of this length being occupied by the crown, the rest by the fang of the tooth. The fang is an inch wide where it passes beyond the alveolar margin of the jaw. It is nearly straight and seems to have been slightly compressed from side to side. The crown is laterally compressed, slightly curved, and tapers to a point. Its anterior longitudinal contour is convex; the posterior is concave, and formed by a ridge with a serrated free margin. I observed traces of the former contour of a large tooth in the middle of the wide interval between the first and the second tooth.

The second tooth is the biggest of all, and projects for nearly three inches beyond the alveolar margin of the jaw. Of this three inches, 2·7 inches is occupied by the enamelled, pointed, and laterally compressed crown, which is much more curved than that of the first tooth. Where the fang passes under the alveolar margin it is 1·2 in. wide. The circumference of the fang at this point has an ovate contour, the front curve being much flatter than the hinder. The same general character is preserved in the crown for 1·7 inch below the commencement of the enamel; but between this and the apex, the middle line of the anterior face of the crown is raised into a sharp serrated ridge, similar to that which occupies the whole extent of the middle line of the posterior face of the crown, and even, as in the first tooth, extends upwards on the fang, a little beyond the line of the rest of the enamel, before it comes to an end. The crowns of the third and sixth teeth resemble that of the second; those of the fourth and fifth teeth are broken. The three hinder teeth gradually diminish in size, their extra-alveolar lengths and greatest diameter being respectively

IV.		V.		VI.	
in.	in.	in.	in.	in.	in.
2·7	0·9	2·3	0·8	1·75	0·7

The teeth are quite free from the jaw, being merely applied against the outer wall of the alveolar groove, which extends very far beyond the inner; so that the alveolar groove is relatively very short and can only lodge the teeth in the earliest stage of their development.

Note.—The skull of a young Dinosaurian reptile, either identical with or very closely allied to *Iguanodon Mantelli*, has been discovered by the Rev. W. Fox in the Wealden formation of the Isle of Wight, at Cowleage Chine, and was exhibited, on his behalf, at the Norwich Meeting of the British Association by Mr. Fellows. On that occasion I made some remarks in Section C upon the characters presented by this very interesting specimen; and as Mr. Fox has kindly permitted me to have the fossil for examination, I propose to submit a detailed account of it to the Society on a future occasion. For the present I content myself with observing that the form of the snout is totally different from that exhibited by *Megalosaurus*. The præmaxilla is produced into a prolongation which seems to have been edentulous, though sharp and conical teeth project from the hinder half of the alveolar margin of the bone. Each præmaxilla sends two processes upwards and backwards, one in front of, and one behind, the nasal aperture, to meet the large nasal bone.

Discussion.

Mr. Boyd Dawkins made some remarks as to the stratigraphical range of *Megalosaurus*. The oldest example with which he was acquainted was a tooth from the Lias of Lyme. It occurred also in the Lower Oolite of Dorset. Higher up it was found in the Kimmeridge Clay, and again in the Tilgate Beds of the Wealden. He had, however, himself found it in the Wadhurst Clay, above the Ashdown Sands, near Battle. He had also seen remains in still higher beds, possibly of Lower-Greensand age, at Potton; but in this case the bones were probably derivative. An animal with almost identical teeth, the *Teratosaurus suevicus* of Von Meyer, occurred in the Lower Keuper, and possibly might belong to the same generic form.

The President agreed that the Dinosaurians had occurred in the Trias, and that he was quite prepared for an extension of the family into earlier beds.

June 9, 1869.

William Shelford, Esq., Memb. Inst. C.E., 7 Westminster Chambers, Victoria Street, S.W.; E. Teschemacher, Esq., 1 Highbury Park, N.; George Ludovic Houstoun, Esq., of Johnstone Castle, Renfrewshire; and T. P. Barkas, Esq., Newcastle-upon-Tyne, were elected Fellows of the Society.

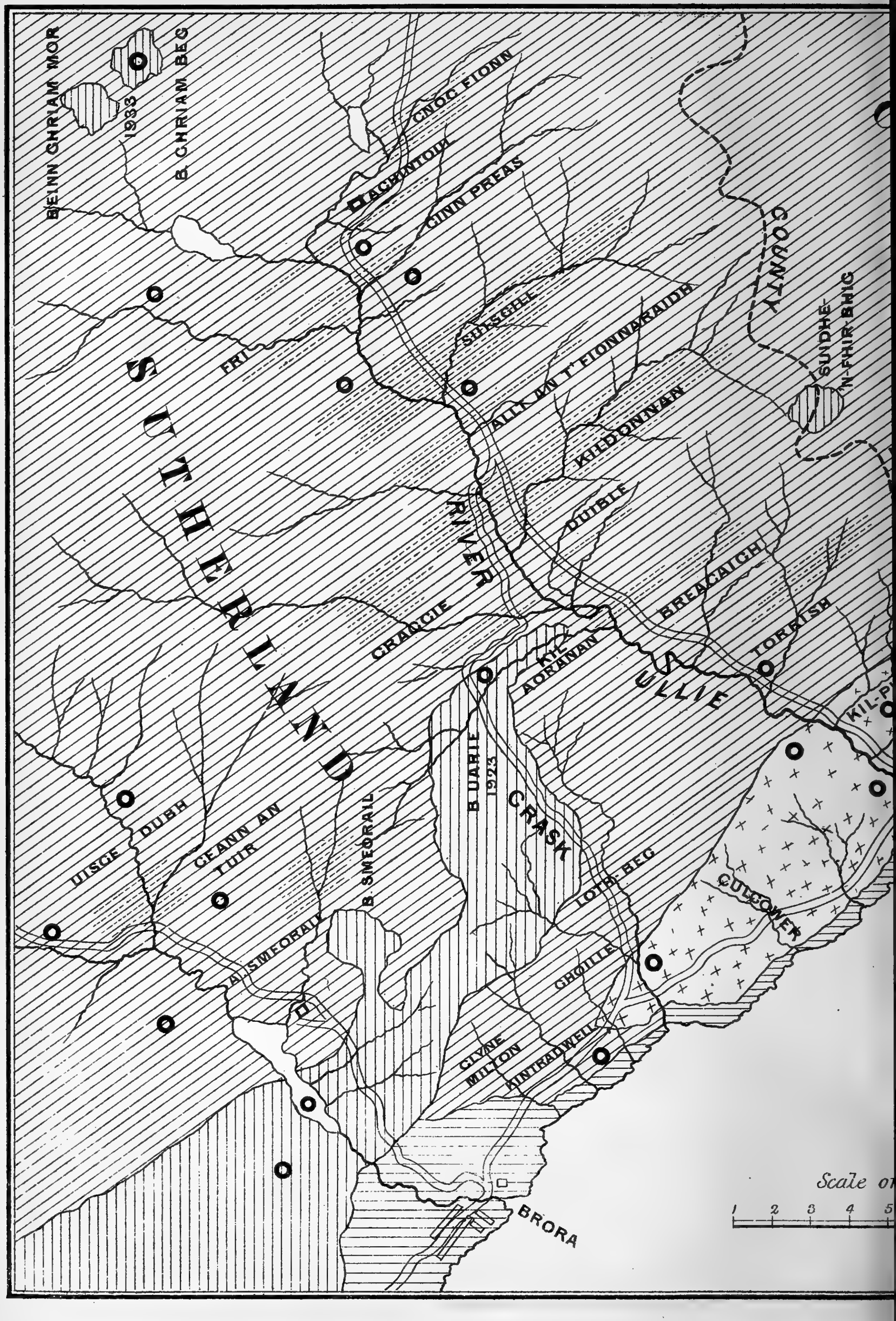
The following communications were read:—

1. *Notes on the* Sutherland Gold-field. By the Rev. J. M. Joass. *With an Introduction by* Sir Roderick I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

[Plate XIII.]

Introduction.

The district of Sutherland in which gold has been recently discovered and worked, in certain waterworn materials and gravelly detritus which cover the crystalline Lower Silurian rocks in several depressions at and near Kildonnan in Sutherland, is the eastern extremity of a region which I have personally explored at intervals for the last forty-three years. It was, however, only in the year 1858 that I fully satisfied myself as to the relative ages and order of superposition and character of all the various rock-formations which occur between the western and eastern coasts of Sutherland and Ross. It was then that for the first time I was enabled to show distinctly an ascending order from the fundamental gneiss or Laurentian rocks of the northern highlands, through great masses of sandstone and conglomerate of Cambrian age, upwards through overlying quartz-rocks



S. E. Sutherland

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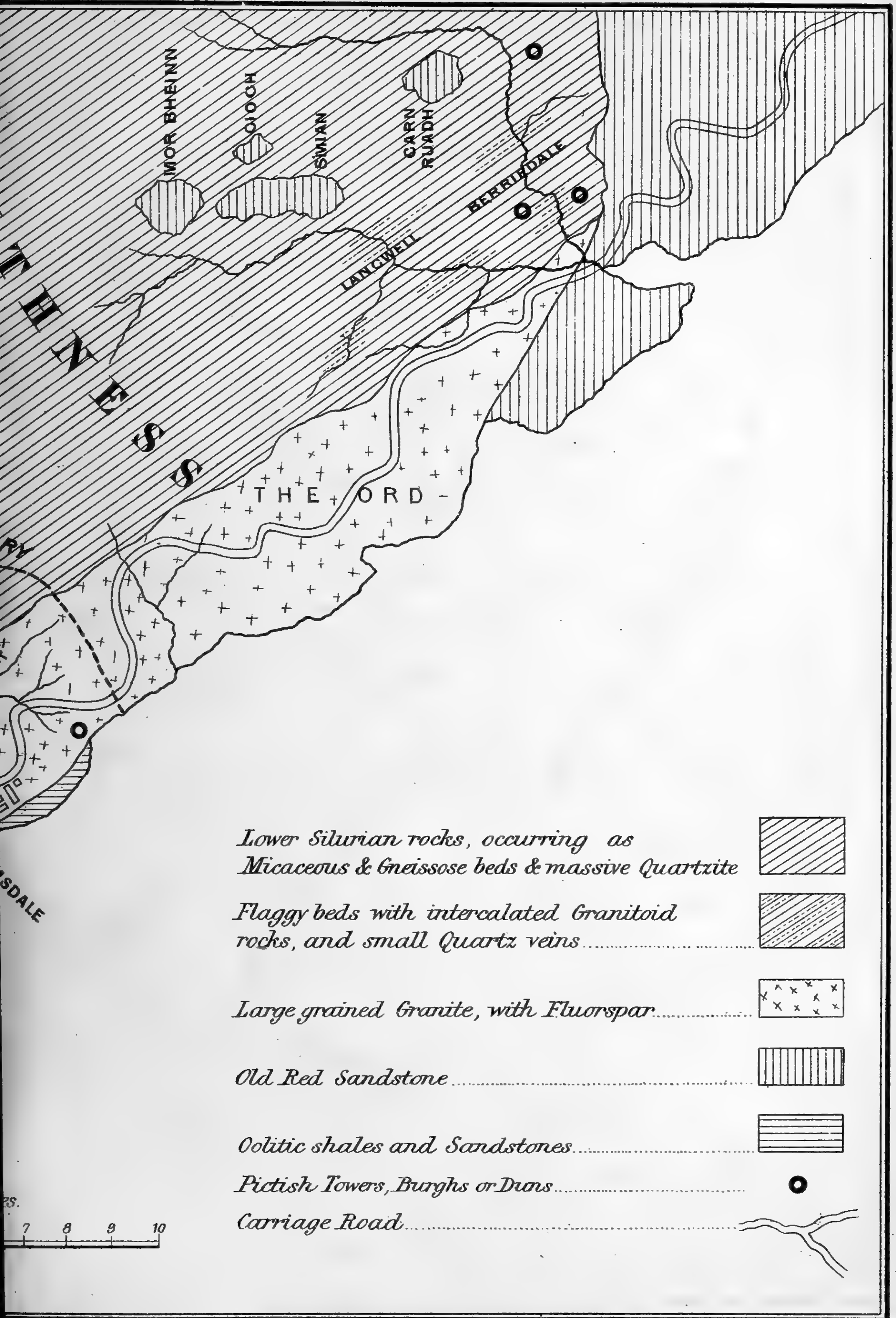

F. Dangerfield lith.

rt of Caithness.

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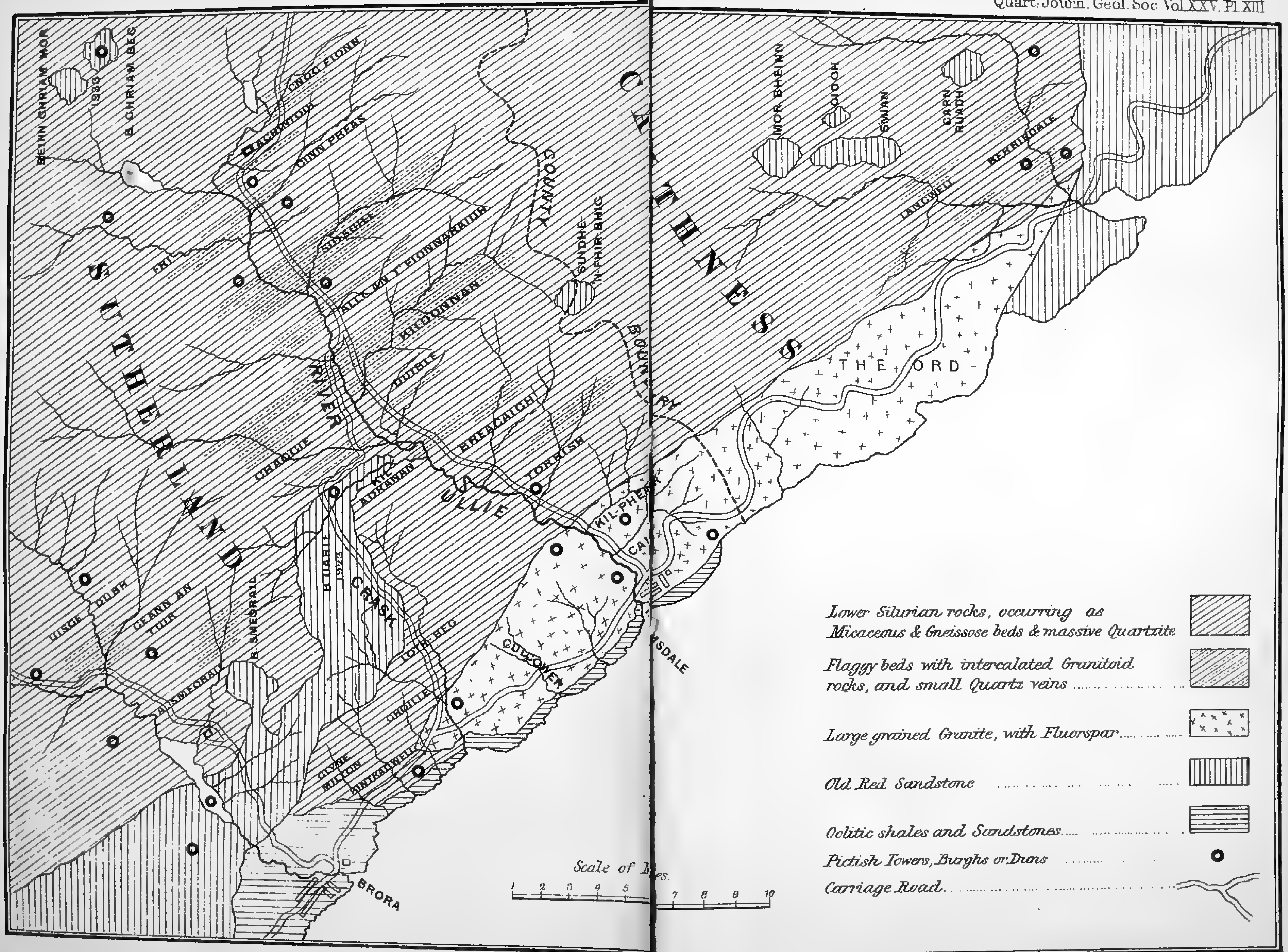


S. E. Sutherland & part of Caithness.

THE GOLD-FIELD,

June, 1869.

and limestones, which, thanks to the fossil discoveries of my friend Mr. C. Peach, were proved to be of Lower-Silurian age. It was also shown that these Lower Silurian rocks, in their extension eastwards and dipping slightly to the east south-east, became more and more crystalline as they trended in that direction, and that when perforated by bosses of eruptive rocks, chiefly granite, they rolled over in undulations in a highly metamorphosed condition, until they were surmounted unconformably by the Old Red Sandstone and younger deposits of the eastern coast.

In order to be able to reason upon the probable sources of the gold detritus which occurs in the gullies (valleys) of such hard crystalline rocks of Eastern Sutherland, it is necessary to recur to those transverse sections from W. to E. which I laid before this Society in 1858, together with a geological sketch map * of the Highlands, in both of which the true general order was first explained.

In referring to these, a chief point which is to be borne in mind is the peculiarity of the outline of the mountainous region of Sutherland and Ross, presenting a steep and rapid escarpment, down which the waters cascade to the western shore, whilst they flow along a gentle slope for many miles to the eastern shore. Thus the parting of the waters in this region lies within four or five miles, and sometimes less, from the western sea-shore, whilst it is from seventy to eighty miles from the eastern shore, in which long descent the waters flow over the metamorphosed Lower Silurian rocks, with occasional bosses of granitic and other intrusive rocks. Now, however transported (probably by floods carrying great masses of ice, caused by the melting of former glaciers—a view which, in a more extended sense, has recently been applied by Mr. John Campbell, of Islay†, who has examined the localities), it is evident that all the disintegrated materials of the great mass of the western and central Highland rocks must have been transported eastwards. I am, indeed, led to suggest that the gold *débris* found in the environs of Kil-Donnan and Helmsdale are the result of the abrasion of extensive masses of the granitic and metamorphic Lower Silurian rocks which, occupying wild interior tracts, extend eastwards to the district under consideration, where their broken materials have been lodged in the depressions of Eastern Sutherland. Reasoning in this way, and looking to the general character of the rocks between the west and east coast, I am led to think that certain valleys on the long eastern slope of Ross-shire which accompany the line of Loch Shin and the river Oikel may also be found to be slightly auriferous. It is here also to be noted that the gold-bearing detritus of Sutherland occurs in a district which exhibits in its environs the most striking evidence of granitic eruption and of highly metamorphosed rocks.

Thus on the Helmsdale shore we have the grand mountain-mass of granite known as the Ord of Caithness, and on the north of

* See Quart. Journ. Geol. Soc. vol. xv., Section, p. 360, and Map, pl. xii.; also vol. xvi. p. 215.

† See "Something from the Gold-diggings in Sutherland," by the author of 'Frost and Fire,' from 'Odds and Ends,' No. 22.

Kil-Donnan itself there stands out a wall of hard, whitish, brittle quartz-rock, which forms the Scarabin Hills*. These, which I have visited at intervals, suggested to me the idea that they were the result of intense metamorphism of Lower Silurian rocks.

When I first heard of the Sutherland discovery, in January last, I wrote to my friend Mr. Joass, urging him to examine the tract; for I knew that he combined the powers of a good geological observer with those of a skilful artist, and also that, through his residence at Golspie in the neighbourhood, he would be enabled to give us a better account of the real nature of the deposit than any casual visitor. I then found that he had already anticipated my wishes to a great extent; and since then, being encouraged by the Duke of Sutherland, the liberal-minded proprietor of the grounds, and His Grace's chief agent, Mr. G. Loch, M.P., he has greatly extended his acquaintance with the localities. As, fortunately, he has now come to London to tell us his own tale, I have no doubt that my associates will derive a very clear view of all the relations of these auriferous deposits—the more so as the map and sections which he has prepared are worthy of all commendation, and fully explain the detailed and complicated relations of the different rock-masses, with which I was unacquainted.

A note or two embodying my opinion as to the sources from which the Sutherland gold-detritus has been derived may not be out of place. Seeing, as above explained, that the transport of the great mass of the auriferous materials in question has in all probability been from W.N.W. to E.S.E., we have now to consider the composition of the successive rock-formations which present themselves as the observer proceeds from the west to the east coast, in order to form an opinion as to which of the parent rocks may most probably have furnished the gold-detritus.

1. The Laurentian or fundamental gneiss may be excluded from our consideration, not only from its composition and the absence in it of anything like auriferous quartz-veins, but also because it forms for the most part low buttresses only on the west coast, and scarcely anywhere rises to the height of the mountain watershed.

2. The Cambrian rocks are also excluded from our reasoning, for they are simply hard sandstones, grits, and conglomerates, which, clearly exposed in mountain-masses, never exhibit any metalliferous veins, and scarcely ever show any signs of metamorphism. They are entirely discordant to the Laurentian gneiss on which they rest, and are unconformably surmounted by the lowest Silurian rocks of the Highlands.

3. These lowest Silurian rocks, chiefly hard granular quartzite, which rise into lofty mountains, and contain intercalated masses of fossiliferous limestone, are all so thoroughly exposed in precipitous or highly inclined escarpments, that if they contained any auriferous veins the same must have been detected.

4. The next overlying group, consisting of chloritic micaceous flags and schists, which, as they dip away to the E.S.E., become

* In Gaelic, Sceirea Beinn.

more and more gneissic in character, and, perforated as they are at intervals by granitic and porphyritic rocks, have, in all probability, afforded the auriferous detritus of Eastern Sutherland. These rocks, which formerly were not separated from the old or fundamental gneiss, though they have the true Silurian strike from S.W. to N.E. (which is rectangular to the strike of the Laurentian rocks), are in parts intensely metamorphosed, whether it be in the high plateau south and west of Tounge, or where they roll over until they reach the eastern slopes of Sutherland and Ross, having in both localities been powerfully affected by eruptive rocks. Judging, then, from the composition of these various rocks, and particularly those described by Mr. Joass, we need not travel further westward from these eastern slopes than to the great central plateau to look for the origin of the gold-detritus; and when we examine the matrices of the auriferous fragments we find that this inference is sustained by their composition.

Finally, I am led to infer, from my acquaintance with the rock-formations of the North Highlands, that there is little chance of discovering in them any notable bodies of rock *in situ* charged with rich auriferous bands analogous to those which are associated with the Lower-Silurian slates and schists of Australia and California.

Notes on the Sutherland Gold-field. By the Rev. J. M. Joass.

It is proposed to arrange the following remarks as under:—

1. The extent of the gold-field as at present ascertained.
2. The general character of the prevailing rocks.
3. The associated rocks.
4. Detailed descriptions referring to map and sections.
5. Probable source of the gold.
6. General remarks.

1. The extent of country over which gold has been ascertained to occur in the south-east of Sutherland and contiguous portion of Caithness may be stated as measuring 30 miles from east to west, and about 20 from north to south. This is exclusive of several widely detached places in the north-west and south-west of the county, where small quantities of gold are credibly reported to have been found. A few points in the north of Caithness, and Unst, in Shetland, are held to be auriferous.

2. The prevailing rocks of the district are believed, on the authority of Sir R. I. Murchison, to belong to the Lower-Silurian series. This may be regarded as settled by his masterly analysis of the evidence for the intimate connexion of these rocks with large deposits on the north-west, which from their included fossils are admitted to belong to that system. Within the district referred to, these rocks occur as flaggy micaceous, gneissose, and quartzose strata, with a south-easterly dip. With a few local exceptions this dip is unaffected by the presence of numerous igneous rocks, whose

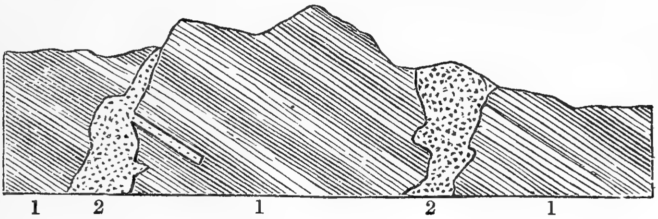
courses conform to the strike of the sedimentary strata, which are all more or less metamorphosed.

3. Resting upon the upturned and denuded edges of these Lower Silurians occurs the Old Red Sandstone, forming a bold line of mammillated cliffs along the southern sea board, as at Cambusmore and Craig-an-airgiod, and stretching into the interior in detached mountain-masses, as at Beinn Uarie and the Beinn-a-ghriams in Sutherland, Mor-bheinn, the Smians and Maiden-pap in Caithness, and Suidhe-'n-fhir-bhig on the county march. These Old-Red-Sandstone conglomerates underlie brownish gritty beds, passing upwards at Dornoch into thick-bedded, light-coloured sandstone, where the occurrence of Holoptychian scales and fucoid plants suggests their belonging to the upper part of the middle zone of the series as subdivided by Sir R. Murchison.

Along the coast, from Golspie to the Ord of Caithness, rocks of Liassic and Oolitic age occur, chiefly as low skerries or reefs, much flexed, and with a general northerly dip, but conforming occasionally in their curves to the present contour of the coast, as they dip at high angles off its headlands or border its bays. At Clyne these rocks pass from the Lias of Dunrobin, with its *Hippopodium ponderosum* and other characteristic fossils, into thick-bedded siliceous sandstones of Oolitic age, some of whose very numerous fossil forms are believed to be nearly allied to those of the Greensand. Here glacial striæ from N.W. to S.E. are beautifully preserved on the highly indurated and almost cherty sandstone. Below this occurs the lignite known and once worked as the Brora coal, while to the eastward, as at Kintradwell and Culgower, *Plesiosaurus* has recently been found, together with a new species of the genus *Gyrodus*, now named by Sir Philip De M. G. Egerton *Gyrodus Goweri*.

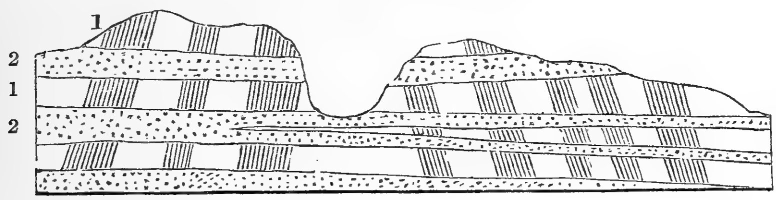
The associated igneous rocks are a large-grained porphyritic granite (*a*) ranging along the coast from near Allt-choille on the south to the burn of Ousdale on the N.E., a distance of about 15 miles, with a breadth of 3½ miles at Kil-Pheadar on the river Ullie or Helmsdale. This rock forms the mountain-mass of the Ord of Caithness, at which point, and at Culgower, it has been found to contain a considerable quantity of purple fluorspar. True granites and syenites, with bosses of hornblendic rock and greenstone, occur towards the west in Strathfleet, a variety most abundant in the auriferous district being a red small-grained granite (*b*), generally associated with beds more or less micaceous, to the strike of which its main courses conform; while it occasionally sends out across the strata, as if into transverse fissures, short dykes from which small veins insert themselves between the micaceous beds as along lines of least resistance (fig. 1). In the most richly auriferous localities, certain granitoid rocks, chiefly felspathic (*c*), are so intimately connected by interlamination with the flaggy quartzose strata, that they almost appear to be the result of metamorphic action upon true sedimentary rocks of the quartzose series, or contemporaneous effusions of plutonic rock. This granitiform rock appears, at least in one instance, to traverse, across the strike, decomposed gneissose strata (fig. 2). In a paper "On the Metamorphic Rocks of the Banffshire coast, the Scarabins, and a portion of

Fig. 1.—*Section showing Granite in Mica-schist at Kil-Donnan Lodge.*



1. Micaceous beds, dipping N.E. 2. Granite (*b*).

Fig. 2.—*Granitiform rock in decomposed Gneiss, Suisgill.*



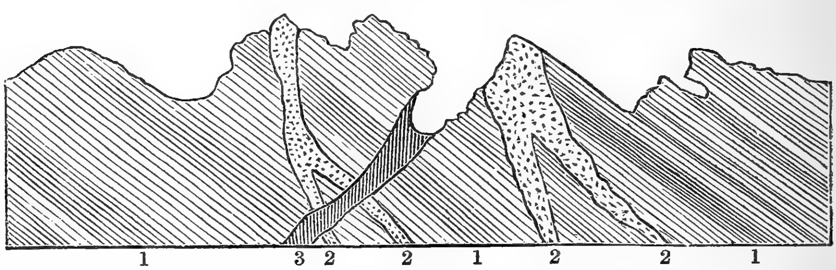
1. Decomposed gneissose rocks, dipping S.S.W. and E.S.E.
2. Granitoid rock (*c*).

East Sutherland," read before the Geological Society in May 1862, Prof. Harkness says:—"The correspondence of the strike of the plutonic masses with that of the metamorphic rocks has been noticed in connexion with these several rocks in Banffshire. In Sutherland it is even more apparent, and supports the inference that here plutonic masses do not perform the office of axes. Their mode of occurrence rather tends to the conclusion that the sedimentary rocks were elevated, flexured, and contorted previous to the period when the granites made their appearance in the sedimentary rocks, and that the granites have conformed in their course to the strike of the previously elevated strata. There are here abundant features which would support the conclusion that granite is, in this district, rather the result of an excessive amount of metamorphic action than a plutonic rock as regards its origin." I venture to think that the coarse-grained porphyritic granite of the Ord (*a*) should perhaps be regarded as truly plutonic and associated with upheaval, from its coincidence in strike with a great line of fault which traverses Scotland from N.E. to S.W. along the great Caledonian valley.

It is true, indeed, that instead of dipping away from this supposed plutonic and upheaving mass the strata to the N.W. dip towards it, becoming almost vertical as they approach the line of contact. This, however, might be accounted for on the supposition that the upheaved and disrupted rocks, already dipping towards the intrusive mass, would, until it hardened and could support them, dip still more decidedly in the same direction as the result of their weight;

while at the opposite point of contact on the S.E. the existing dip might remain comparatively unaffected. The upheaval along this line of fault, with which the porphyritic rock (*a*) is believed to be contemporaneous, probably took place prior to the deposition of the Old Red Sandstone, which, overlying the Lower Silurian rocks unconformably, dips generally seawards in accommodation to what would seem to have been a previously elevated coast-line. Throughout the auriferous district the red granite (*b*) appears to answer the description given by Prof. Harkness—an intrusive rock "conforming in its course to the strike of the previously elevated strata." The binary compound of felspar and quartz referred to as granitoid (*c*), and apparently associated with the richest auriferous drifts, seems in many instances to suggest a metamorphosed Lower Silurian rock whose particles, yielding to such agencies as heat and electricity, were melted and mineralized *in situ.* It does not appear to me altogether inconsistent with this opinion that the rock in question, which is as thinly bedded as the flaggy sedimentary strata, and alternates with these, whether they be gneissose, quartzose, or micaceous, should occur as a short transverse dyke, as it seems to do at Suisgill (fig. 2). If we suppose that fissures caused by local upheaval might have been contemporaneous with an exhibition of metamorphic action, these fissures would be filled by a molten rock, whether its materials were supplied on the spot or intruded from beneath. If, however, it can be shown that rocks are never melted by the agencies which conduce to metamorphism, then both *b* and *c* seem to

Fig. 3.—*Granite and Trap in Mica-schist, above Crask Bridge, and near Kil-Donnan Lodge.*



1. Micaceous Schist, dipping N.E. 2. Granite (*b*). 3. Trap Dyke.

be as truly plutonic and intrusive as the trap-dyke at Crask Bridge on the Ullie (fig. 3).

4. Referring to the accompanying map of the auriferous district, (Plate XIII.) I beg to offer a few detailed descriptions, beginning on the S.W. at

Strathbrora.

The Uisge-dubh, or Blackwater, runs nearly across the strike of highly inclined flaggy quartzites and micaceous schists, whose dip ranges from S. to E. At the waterfall, below Ceann-an-tuir, granite (*b*) appears among beds of micaceous schist which have been dislocated by a fault. Parallel courses of this rock recur at short intervals up stream, alternating with softer gneissose rocks and micaceous schists, with an occasional thin bed of white felspathic rock, *c*. Here gold is found in small scales by washing the overlying drift, which consists of a dark blue clay, containing rolled fragments of red granite and quartz, and is overlain by yellowish clays, gravel, and sand, all apparently arranged by running water. The lower part of this stream runs through shingle, and finally between steep banks of black alluvium, till it enters Loch Brora. Falling into this loch from the north-east, Allt-Smeorail, or the Gordon-bush burn, emerges near the road from a deep ravine, where the rocks are well displayed. These dip E. and S.E. at a high angle, and consist of flaggy quartzites and micaceous beds, with associated granitiform rocks, red and pink, among which are *b* and *c*, and a few quartz-veins. The granites never flex the neighbouring strata; the quartz-veins occasionally do. The gritty drift, or gold-wash, is here overlain by reddish-clay and sand, derived apparently from the detritus of Beinn-Smeorail, a conglomerate mountain capping unconformably flaggy quartzose and gneissose beds. Old-town and Clais-mor burns, both tributaries of the Brora from the east, run through red boulder-clay and over Old Red Sandstone, which is the underlying rock, to the junction with the Clyne Oolite. No gold was found in either of these two streams.

The Coast.

A very small quantity of gold was found at the head of the Clyne-Millton burn to the eastward, where flaggy quartzites occur. Kintradwell burn runs in a deep ravine cut through yellowish boulder-clay. The channel is almost covered by boulders of granite and sandstone; but a small section of a rock *in situ* shows flaggy gneiss dipping E.S.E. Allt-Choille is a deep and rugged ravine, the lower part of which is cut through boulder-clay and soft oolitic sandstone. Near the bridge the rocks are highly indurated and quartzose, containing carbonate of iron in thin seams and drusy cavities. No gold has been found either in Kintradwell or Allt-Choille.

Glen Loth.

The Loth-beg Water runs its lower course over a red porphyritic granite, resembling that of the Ord. In Sletdale burn, a tributary from the west, a few flaggy gneissose rocks are seen above the bridge dipping E.S.E. The course of this stream, in its upper reaches, is over gravel and through peat moss, concealing the junction which here takes place between the Lower Silurian and Old Red Sandstone.

On the shoulder of the hill which bounds the opening of Glen Loth to the east, large-grained porphyritic granite crops out, in many places highly ferruginous. This rock is believed to persist to the Ord of Caithness, as it is visible at intervals along the hill-side, and forms the bed of the Culgower burn and the mountains that overhang the opening of Strath Ullie or the Helmsdale valley.

Pursuing the course of the Glen-Loth stream upwards, the rocks, where visible in the escarpments of the lofty mountains to the left, are Old-Red-Sandstone conglomerate. Striated boulders of brown sandstone of great size lie scattered about the lower slopes; and at Kilaornan burn these brownish grits and argillaceous flags occur *in situ*, and form the material of the neighbouring Pictish tower. The next stream northward is Craggie burn. Here the flaggy gneissose rocks reappear, dipping E.S.E. at a high angle, associated with thin seams of the quartzo-felspathic rock *c*. No gold has been found in Loth-beg Water, nor in the Kilaornan burn; but Craggie burn has proved auriferous.

Strath Ullie.

In the bed of the Ullie or Helmsdale, above the Crask bridge, and near Kil-Donnan Lodge, flaggy micaceous and gneissose beds are traversed by granite *b*, which is itself intersected by a dyke of dark brown trap. This crosses the strata and associated crystalline rock, but without affecting the dip, which is here N.E. (fig. 3). Further up stream the schistose rocks become harder and more flaggy in character, and the dip changes slightly to the eastward, unaffected apparently by the presence of the granitic rocks, which occur as thick bands, throwing out veins in all directions, which sometimes follow the seams, and suddenly cease when about an inch thick (fig. 1). Very rich washings were found here in the rocky pockets by the river-side, the overlying drift being particoloured clay with white bands and blotches, covered with ferruginous gravel and sand.

Passing for the present the mouth of the Suisgill burn, which flows into the Ullie from the north, about two miles from this point, we reach the river Fri, flowing from the west. Here micaceous and gneissose flags dip E.S.E., with some intercalated granites. These, generally large-grained and friable, become more numerous as we proceed towards Achintoul, beyond which, in the Cnock-fionn river, running from the N.E., they become very abundant. Here the dip is still easterly and at a high angle. A little gold has been found in the stream last mentioned. Hereaway the country becomes deeply boggy, the first prominent rocks, about eight miles to the north-west being the lofty twin mountains Beinn-Ghriam-mor and Beinn-Ghriam-beg, isolated masses of Old Red Sandstone, dipping S.W., and furnishing most imposing evidence of immense denudation.

Returning from Achintoul by the Strath-Ullie road, five miles bring us to Cinn-preas burn, a north-eastern tributary of the Ullie. Here red granitiform rocks and flaggy beds occur, dipping east. A small nugget, weighing 5 dwts., was found here, and a good deal of granular gold.

Suisgill, the next stream from the north-east, was early visited by the diggers, and is still their favourite resort. The gold found here is generally in larger pellicles, and has hitherto been sufficiently abundant to yield a very fair return for skilled labour. Flaggy gneissose rocks, with a few micaceous beds, dip here E. and E.S.E.; but the feature of its lithology is the abundance of a binary compound of felspar and quartz (*c*), commonly interbedded with, but once apparently intersecting, the strata.

The more felspathic varieties of this granitoid rock are readily disintegrated, forming either a white plastic clay or a gritty siliceous sand, according to the predominance respectively of felspar or quartz. Towards the head of the stream, this and other granitiform rocks, large-grained, pinkish, and friable, become abundant, forming great slopes of granular grit, from which the locality at the Suisgill forks takes its Celtic name of Feithegaineamhaich, or the Sandy Swamp. The same name, and for a similar reason, is given to the head of one of the streams running into the Langwell Water, in the neighbouring district of Caithness.

In the small stream Allt-an-t'fhionnaraidh, to the south-east of Suisgill, a water-rolled pellet, about $\frac{1}{2}$ inch in diameter, and containing gold in intimate connexion with felspar and quartz, was recently picked up without washing. So far as the origin of the gold may be inferred from such a small specimen, it suggests the binary granitiform layers and grits of the upper Suisgill.

In Kil-Donnan burn, where, as is now generally known, the Sutherland gold was first discovered by Mr. R. N. Gilchrist, a native of the county, on his return after a seventeen years' residence in Australia, the flaggy rocks are generally quartzose and gneissose, dipping E. and E.S.E., with an occasional veer to the N.E. Quartz-veins of small size occur here, generally encased in chloritic clay. The felspathic rock *c* is also present, but not in abundance. The drift, which at its contact with the bottom rock, sometimes consists of bluish and yellow clay with light-coloured patches, is most frequently, as in Suisgill, a ferruginous gravel with rolled boulders, apparently of local origin. Above occurs yellowish clay, overlain by coarse sand, containing dark flexed earthy lines in section, the whole covered by thin peat moss. Gold is found in the greatest quantity in the lowest portion of the alluvium, but is obtained occasionally from wash-dirt immediately under the surface turf (fig. 4).

In the streams which run into the Ullie from the N.E., between Kil-Donnan and Kil-Pheadar (namely Allt-duible, or the double burn, which runs into one before reaching the river, Allt-bhreacaich, the speckled burn, from the quantity of quartz lying about its slopes, and Allt-torrish, the burn of mounds, from its numerous prehistoric tumuli), the rocks preserve the same character and general easterly dip, with some slight local variations. All these streams are auriferous, but not richly so. Kil-Pheadar and Caien burns traverse the granite of the Ord; and no gold has been discovered in them, although their nearness to Helmsdale village, where many of the miners lodge, prompted and facilitated careful and frequent search.

The same persistence of easterly dip is traceable as we cross the strike to the Old Red Sandstone at Berriedale, on the Caithness coast. The rocks, however, become more quartzose till they pass upwards into the quartzite mountains of the Sgerreabeinn range. The occurrence of these quartzites, and the fact that prospecting was prohibited within the Berriedale district, probably occasioned the very general belief that it was richly auriferous. Two large parties of miners did indeed forcibly enter the ground, but found so little as to discourage their return at the risk of violating the law. By the kindness of His Grace the Duke of Portland I was enabled to make a careful examination of all the rocks in the Langwell and Berriedale valleys, traversing the mountains, and examining every rocky stream; and so far as such search is conclusive, apart from washing for gold, I should be inclined to think that this district is less likely to prove auriferous than that on the Sutherland side of the ridge between Cnock-nan-Eirinneach and Suidhe-'n-fhir-bhig, the line of the county march.

This opinion is of course solely founded upon the apparent absence of those rocks which seem to be associated with the richest deposits in the district of Kil-Donnan.

5. The source of the gold, however, is still undiscovered, since nowhere has it yet been found in rock *in situ*. Several specimens of water-rolled stone, rich in gold, have been found in Suisgill and Kil-Donnan burns: these, with the specimen already referred to, are now exhibited; and it will be seen that in every instance the components of the stone are felspar and quartz, with one exception, in which the rock is quartz only, but not such a large fragment as may not have belonged to the quartzo-felspathic rock *c*. Arguing from the comparative poverty of the drift where this rock or its detritus is scarce, and connecting its prevalence in Suisgill and Kil-Donnan with the rich alluvium there, we may venture, I think, to infer from these facts and those rock-specimens that the granitiform rock *c* may yet be found to be the matrix of the gold.

Fig. 4.—*Section showing Alluvial Deposits in Kil-Donnan.*

a. Peat-moss. *b*. Stratified sand and clay. *c*. Ferruginous gravel with boulders, the common wash-dirt of the miners, containing gold, garnets, and magnetic iron-ore. *d*. Granite (*b*). *e*. Flaggy gneissose and quartzose rocks, dipping S.E., E., and E.N.E. *f*. Quartz-veins. *g*. Hornblende rock, with iron-pyrites. *h*. Quartzite. × Felspathic clay.

6. The material in which the granular gold occurs, namely the detritus overlying the abraded edges of the flaggy Lower Silurian rocks, may be partly of glacial origin, but is not necessarily far-travelled, for its included boulders seem to be of local origin. It has been arranged by water, but probably that of the streams near which it lies and not that of the sea, judging from the unwashed moraines which occur at lower levels in the valley of the Brora.

The extent of the auriferous country will probably be found to correspond with the range of the more highly metamorphosed Lower Silurian rocks; and since these may be found in more or less force as far as the northern coast of Sutherland, the area of the gold-field may yet, perhaps, be extended. Nearly every stream within the area here described has been well searched by practical diggers; and the fact that many of them, as already mentioned, have been searched in vain, suggests no wide-spread deposit, the result of extensive glaciation, but several independent centres connected with the local rocks.

The question of the continuance of gold-seeking as a source of remunerative labour must depend upon the extent to which these its parent rocks may be found to occur. This can only be ascertained by systematic prospecting, which will doubtless be encouraged when questions now pending between the agents of the Crown and those of the noble proprietor of the ground are satisfactorily settled.

Already the results have been a fair return for skilled labour, amounting to the value of about £3000, so far as I can ascertain by inquiry and careful calculation.

In conclusion, it may perhaps not be held irrelevant to remark that the Pictish Towers, a class of ancient buildings very numerous in Sutherland, are specially abundant within the ascertained auriferous district, and further appear, wherever they occur, from Shetland to the south of Inverness-shire, to be associated with rocks which may be more or less auriferous—namely the Lower Silurian, believed on very high authority to be the most frequent source of gold in all parts of the world.

These forts were apparently erected against maritime invaders. Their number and strength suggest the frequency and formidable nature of such invasions, for which a motive may be found in the supposition that south-eastern Sutherland and other districts where such duns or burgs occur were known in prehistoric times to be rich in gold or other mineral treasures. Hence, perhaps, the connexion between the copper of Sandness and Mousa-burg in Shetland, the lead and silver of Beaufort and Struidh-burg in Inverness, the gold of Durness and Dun-Dornadilla in West Sutherland, of Uisge-dubh and Caisteal-Coille, of Allt-Smeorail with Aschoille-burg on one side, and Coir-Aoiscaig tower on the other, and of Strath Ullie, with its chain of Pictish strongholds from Dun-uaine on the coast to the wonderful group of Cyclopean structures that crown Beinn-Ghriam-beg twenty-eight miles inland.

Hence, too, perhaps, the origin of the native torques and armillæ of beaten gold, attractive booty no doubt to the roving Norsemen, "the exactors of rings;" and hence, also, it may be, one reason why the largest nugget lately found weighs only 2 oz. 17 dwts., if we suppose that the gold discoverable without washing or other modern appliances had been picked up by the prehistoric people.

Discussion.

Prof. Ramsay regarded it as certain that no quantity of gold would ever be found in purely glacial deposits, as in such detritus specific gravity went for nothing; but when those deposits came to be sorted by water, the gold became apparent, as in this case. He agreed with the author in regarding the granites in Kil-Donnan burn as metamorphic rather than intrusive, and had long held this opinion. The felspathic dykes were probably due to other causes.

Mr. D. Forbes, on the contrary, regarded the granite as eruptive, and accounted for the granitic veins following the lines of stratification, inasmuch as those were the lines of least resistance. The smaller interstices caused by the intrusion of the granite would be filled with quartz-veins derived from the granite, both probably containing gold. He considered that the gold had not been derived from Silurian rocks, but from the intruded granite or from the quartz-veins.

The Author was inclined to regard the granite in some instances as intrusive, and in others as metamorphic.

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2. Observations *on the* "Nuggetty Reef," Mount-Tarrangower Gold-field. By Dr. George H. F. Ulrich, F.G.S.

The Mount-Tarrangower Gold-field lies about eighty-five miles due N.W. of Melbourne, at a mean elevation of 1200 feet above the level of the sea. Mount Tarrangower, from which the field derives its name, is a fine, massive, symmetrical hill, 1844 feet above the level of the sea by barometric measurement, thus rising several hundred feet above the level of the surrounding hilly country, and forming a conspicuous landmark for a great distance round. It and its eastern, northern, and southern spurs consist mainly of bluish-grey, hard, metamorphic Lower-Silurian Sandstone ("Hornfels") which crops out in beds, generally thick, but much cleaved, showing a mean strike of N. 12° W., and an easterly dip of 70°–80°.

About 500 feet down the rather steep western slope of the mount we meet the boundary of the extensive granitic tract, here generally known as "Bryant's Ranges," but forming part of the large horseshoe-shaped mass of which Mount Alexander, near Castlemaine, forms the highest point at an elevation of about 2800 feet. All along this boundary, which runs nearly due N. and S. for above six miles, numerous ramifications of the granite into the metamorphic rock can be observed, and there are also several small patches (inliers) of Silurian rock cropping out of the granite, which show in places round their boundaries an evident gradual passage into dark, fine-grained, micaceous, sometimes gneissose granite. It is singular that the strike and bedding of these Silurian inliers appear to be in no way disturbed or to deviate from those the rock shows beyond the granite boundary. That the granite could scarcely have exerted any upheaving action upon the Silurian formation is well shown by the fact that both the strike and dip of the beds are against the granite, and show no material alteration in these particulars for miles away from the latter.

Close around the foot of Mount Tarrangower, within the north-eastern quadrangle, lies the thriving little mining town of Maldon, enclosing within its boundary some of the richest auriferous quartz-reefs of the district, and forming, as it were, the nucleus from which, towards the north, east, and south, auriferous Postpliocene gullies and chains of hilly patches of Upper Pliocene gold-drift diverge.

Both gullies and drift-hills (once highly auriferous) are now nearly worked out. Washing on a large scale might still perhaps prove a profitable undertaking, if a great scarcity of water did not put this beyond the power of the enterprising miner. The chief resource at present of the mining community of Maldon, and what has made this gold-field celebrated, are its numerous auriferous reefs; and amongst these the one named at the head of this article ("the Nuggetty Reef") is no doubt the most remarkable, both on account of the great quantity of gold obtained from it, and because it exhibits some interesting geological features that throw a clear light upon its age relatively to that of the granite. The reef was discovered in 1856, receiving its name from the coarse, nuggetty gold found in its outcrop, and it has yielded up to the present time very little short of 300,000 ounces of gold; some portions are said to have paid from 300–500 ounces of gold per ton. It lies about two miles and a half N.N.W. of Maldon, appearing first on the surface several chains north of the top of the high east and west range that commences from near this point to form the watershed between the Muckleford and Bradford Creeks, and it terminates against the granite at the foot of the range, diminishing gradually and dividing into thin veins, which do not penetrate that rock. It strikes N. 12° W., and dips easterly at angles varying from 70° to nearly vertical. It cannot in reality be regarded as one well-defined lode, as it consists of separate veins, and shows irregularities and different aspects in different portions of its extent. At the north end, for instance, which is principally worked by the Alliance Company, it consists of two strong veins, divided by a somewhat irregularly shaped and bedded mass of bluish-grey hard, metamorphic sandstone—a so-called "horse," which is more or less abundantly traversed by quartz-strings. At the surface the two veins adjoin each other very closely, and have perhaps once been united in the original crown of the reef, since removed by denudation. Owing, however, to the "horse" gradually expanding to a certain point, then contracting and again increasing in width, the veins diverge, converge, and diverge accordingly.

The eastern vein is distinguished by a fine smooth eastern wall that extends without any change as far as the line of the reef has been opened and examined; the western vein, on the contrary, is devoid of a defined wall, and shows no casings, and the quartz presents an extremely uneven face, ramifying very frequently into the country and the horse (fig. 1). With regard to its auriferous contents, the eastern vein stands far behind the western in richness: although the yields of gold from certain parts have been very fair, still, on the average, they were low, and the character of the vein became irregular in depth; whilst the western vein contained the gold more richly and evenly distributed, and showed a more regular course on being followed downward. It was rarely less than 3 feet, but increased in places to 20 feet and more in width (Crystal's Claim).

Next southward of the Alliance Company, in the ground worked by the Speculation Company, a great alteration is apparent in the character of the horse separating the two veins. It becomes, from the surface downward, gradually more thickly traversed by quartz-strings, which are mostly auriferous, and at about 200 feet in depth it represents in reality a close irregular network of quartz and metamorphic sandstone. One of these strings, near the centre of the "horse," increases to several feet in thickness, becomes well defined in dip and strike, and, being also more auriferous than the rest, is advantageously worked and called the "middle vein." The eastern vein is in this ground not visible on the surface, and was for several years, in fact, not supposed to exist, till, through some workings, to be mentioned further on, and certain features in the neighbouring ground of the Alliance Company, it became clear that the horse expands towards the surface to such a degree as to squeeze the vein to (what the miners term) a "feather-edge," and to make it quite disappear at the surface. On piercing the horse, however, at a lower level by a cross cut, it was soon discovered, and produced some very rich quartz for a certain extent in length and depth, but gradually became poor afterwards. At 240 feet from the surface the western vein showed in this mine the peculiar feature of becoming nearly flat for a distance in strike of about 100 feet, and in dip nearly 40 feet, and then assuming its normal course again (fig. 2). The thickness of the vein at this place is 3–5 feet, and the quartz yielded on an average nearly two ounces of gold per ton.

Proceeding again southward of the Speculation Company's mine, the reef shows a further change. The eastern vein, hitherto less important than the western one, continues profitably auriferous for a considerable extent in strike, and, ultimately disappearing at the surface, still exists in depth, always distinguished by its fine smooth eastern wall; the western vein, on the contrary, soon dies out both in depth and strike.

Having thus given a short sketch of the reef with regard to its development in the principal mines opened upon it, I will now describe some peculiarities observed in the Alliance Company's mine, in connexion with the interesting feature of the intersection of the reef by different granite-veins. The relative positions of these with reference to the company's engine-shaft are as follows:—

The first vein traverses the reef diagonally, entering it close south of the shaft, and running northward through it for a distance of 20 feet, where it cuts into the western wall (fig. 3). It extends with a slight northerly dip to a depth of 120 feet, terminating there quite abruptly in the reef; whether it does so likewise in the

Fig. 1.—*Plan, showing the general character of the Reef.*

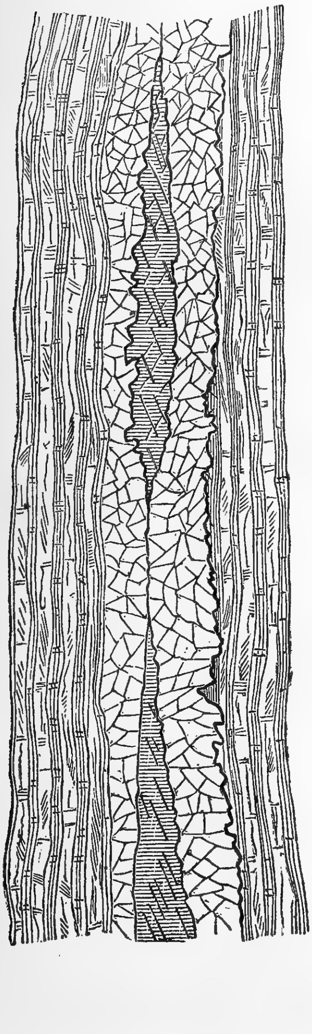


Fig. 2.—*Cross Section, showing bend in the Reef.*

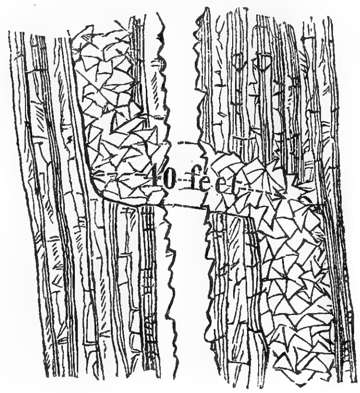
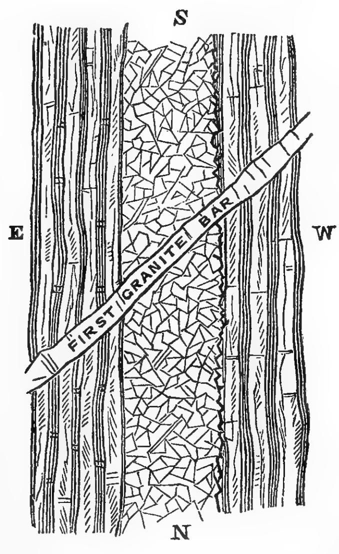


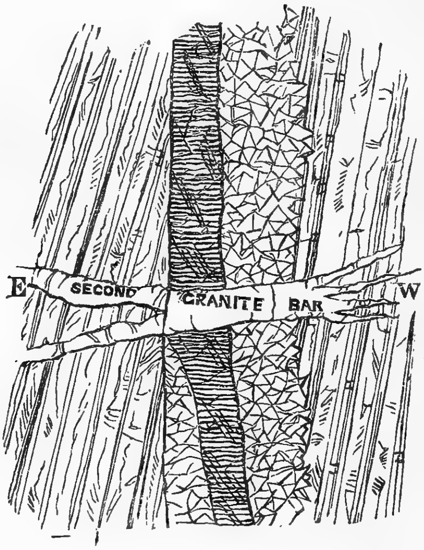
Fig. 3.—*Plan of Reef, showing first bar of Granite.*



country, on both sides, has not been ascertained. It is about 7 feet thick, and consists at the surface of a fine-grained felspathic (euritic) granite; it becomes, however, more coarse-grained in depth. There is no displacement or change observable in the reef where this vein crosses it.

The second granite vein appears at the surface about 10 feet south of the engine-shaft, running right across the reef and dipping southward (irregularly steeper and flatter) at a mean angle of 50°. It is about 6 feet thick and solid where intersecting the reef, but divides on the eastern side into two, and on the western one into apparently a number of branches entering the country (fig. 4). From this vein likewise the reef has not suffered any displacement or change. On being sunk through, the granite was observed to have,

Fig. 4.—*Section of Reef, showing second Granite-vein.*



in a line with the smooth eastern wall of the reef, a distinct joint or crack, filled with black clayey matter. This feature was so deceptive that the miners believed the vein really terminated right at the eastern wall; and as a similar joint, though not so marked, was observed on the western wall also, the belief generally gained ground, and it was at last positively asserted, that this second granite-vein did not penetrate into the country, but formed, so to speak, an intrinsic portion of the reef. However, through a late break in the mine, causing a great portion of the reef and country to cave in at the surface, the fallacy of this assertion is clearly proved, since the branches into which the vein divides can plainly be seen entering the country. The sinking through this granite vein, in the Speculation Company's ground, led principally to the proper understanding of the nature of the previously mentioned "horse," and, in consequence, to the discovery of the easterly vein of the reef. Not knowing that the "horse" expands, and thus causes the easterly vein to disappear towards the surface, the company worked down the westerly vein and penetrated through the granite. But on finding the reef beneath of a far greater width, save a thin parting of metamorphic sandstone in the centre, and also striking the smooth eastern wall, that had not been observed above the granite, it was at once rightly supposed that what had been thus far considered the country was in reality the "horse," which suddenly contracted beneath the granite vein, thereby causing the eastern and western quartz-veins to join. A cross cut and a rise through the granite up the eastern wall were, as already mentioned, successful in striking the former vein above the granite. Figs. 5, 5*a*, 5*b* represent these relations of the "horse," reef, and intrusive vein.

The third vein of granite was struck in the Alliance Company's engine-shaft at a depth of about 240 feet. Its thickness amounts

Fig. 5.—*Plan of Reef, showing Granite Bar and "Horse."*

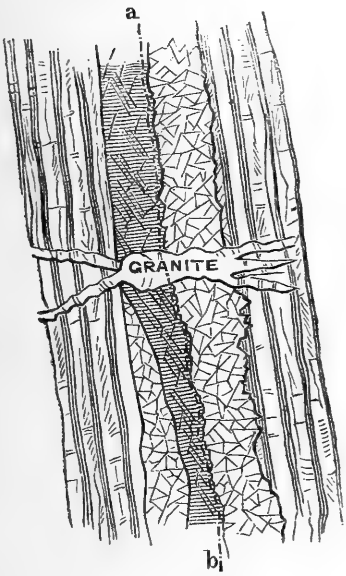


Fig. 5 *b*.—*Cross section of the Reef along line a b of* fig. 5 *a*.

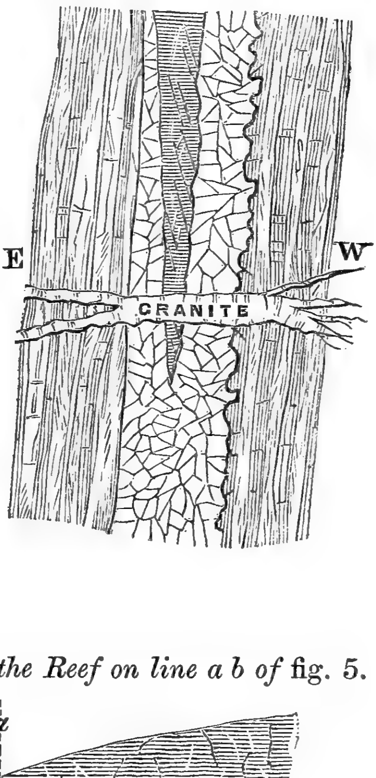
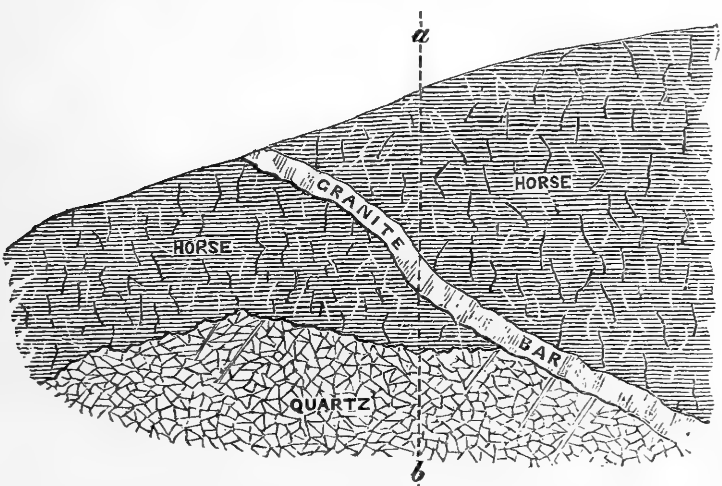


Fig. 5 *a*.—*Section along the strike of the Reef on line a b of* fig. 5.



to nearly 8 feet; and it dips both west and south at angles of 35° through the reef. The latter is at this point nearly vertical, and shows, as was the case with the former two veins, no dislocation whatever; but it was found to be quite poor, nearly barren, underneath the granite, though pretty rich above it, and the "horse" dividing the reef gradually widened again in depth, whilst for a good height above, towards the second granite-vein, it had been nearly absent (fig. 6).

The fourth granite vein that traverses the reef is from 5 to 8 inches thick, and dips E. at an angle of about 20° with a slight northerly in-

Fig. 6.—*Cross section of the Reef, showing third vein of Granite and "Horse."*

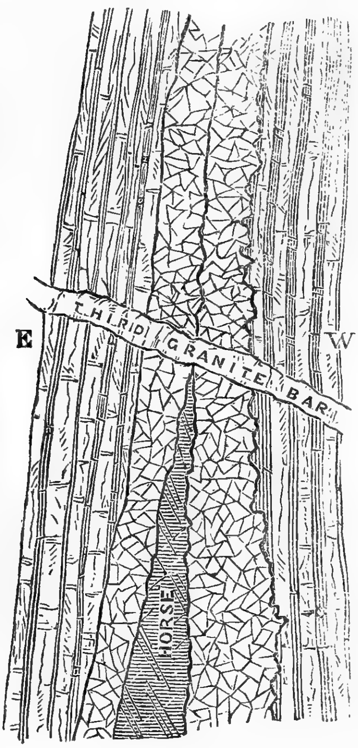
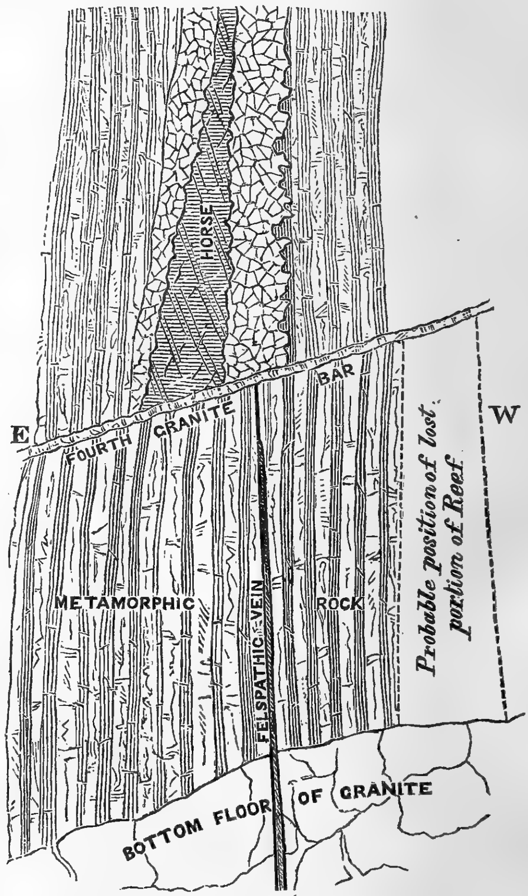


Fig. 7.—*Cross Section, showing fourth Granite-vein cutting off the Reef (eastern and western veins with "Horse" between) and probable position of lost portion, also granite bottom floor and felspathic vein.*



clination. It was struck in the engine-shaft at a depth of 430 feet, where the reef, as a whole, has a width of nearly 50 feet, of which the western vein represents about 20 feet, the "horse" about 25 feet, and the eastern vein 4–5 feet. Beneath the granite all traces of the reef are absent, and only the hard blue metamorphic sandstone of the district occupies the place. The company deepened their shaft through this rock to a depth of 490 feet, when granite, dipping east at an angle of 18°, was again struck and sunk into for 20 feet. But as it showed no change of any kind (being solid, and nearly without joint or crack), further sinking was considered useless, under the, no doubt well-founded, supposition that this last granite represented the real massive formation of the rock, dipping this way from the neighbouring surface-boundary, and not, as was at first hoped, a strong vein or bar like those before described. The only exceptional feature met with, whilst sinking the shaft through the metamorphic sandstone underneath the fourth granite-vein, was a vein of white "orthoclase" mixed with some quartz, which commenced at first quite thin right underneath the former vein, but soon thickened to 3–4 inches, and was never lost for the whole distance sunk, dipping nearly vertically through both the sandstone and the granite. It sadly deceived the poor miners for a good while, as they mistook the felspar for quartz, and considered the vein to be a fresh "making" of the reef. After the shaft-sinking was discontinued, it was noticed that the relation of the fourth granite-vein to the reef furnished strong evidence of the latter being faulted by the former; and a cross cut, starting right on the top of the bottom floor of granite, was driven eastward in search of the faulted portion. No signs of the reef being, however, met with after a distance of 70 feet was reached, this work has likewise been discontinued, and it is now contemplated to cross-cut westward—a direction which ought, in fact, to have been tried at first; for, according to the old mining rule, that the hanging portion of a faulted lode has in most cases slid down in the direction of the dip of the faulter, it is the most likely side on which the reef might be regained (fig. 7).

The four granite-veins described have, as mentioned in the beginning, been observed in the mine of the Alliance Company; in the the neighbouring mine of the Speculation Company only the second vein that dips in this direction (southward) has as yet been struck, the first vein lying wholly in the Alliance Company's ground, and the third and fourth occurring at a lower level than the workings in this mine have reached. Lately, however, a granite-vein has been struck in it at a depth of 200 feet, which is evidently quite new, *i. e.* different from the other four veins, as it has only a thickness of 1–2 feet, dips nearly vertically, and runs obliquely across the reef. It is at present exposed in one drive only; but as the workings progress it will be interesting to observe whether it stands in connexion with the second and third granite-veins, which lie respectively above and below it.

With regard to the mineral character of the granite of the veins, as compared with that of the granite of the main mass in the immediate neighbourhood, hardly any difference can be observed, except that the vein-granite appears to be slightly more quartzose, and to contain perhaps less mica than the other. It can scarcely be doubted that the two lower granite-veins and the bottom floor are still in connexion with the main mass, and would lead up to it if followed northward; whilst the other veins were originally so connected, though all traces of this have since disappeared by denudation. Yet the assumption that the first three veins especially are intrusive appears to be singularly at variance with the mode of their mineral connexion with the reef. The feature generally observable between intrusive dykes and the surrounding rock (a division-line between the quartz and granite) is completely absent. The granite appears here, in fact, not at all unlike a zone of impregnation, inasmuch as the quartz, some distance above the veins, shows first scattered crystals and particles of felspar; these increase in quantity; plates and small nests of black mica appear, and, whilst their number also augments, the mixture becomes more and more fine-grained, and the passage to typical granite is insensibly completed, the reverse process of change of this rock to reef-quartz commencing again a few feet below. The definite thickness given to each granite-vein in the previous description has only reference to the zone of typical granite; if those portions of the reef above and below which bear already a marked granitic character were to be included, the width of each vein would perhaps be double that given. Even the gold and the other minerals associated with it in the reef take part in the above passage, for they have been found several inches deep in the granite; in the centres of the veins, however, none could be detected. Mr. Salter, the Manager of the Alliance Company, presented to the Melbourne Public Museum several fine specimens, showing the gradual change of quartz to granite, examples of vein-granite with specks of gold, pyrites, &c., and also one specimen from the lowest (fourth) vein, consisting of quartz, granite, and metamorphic rock. Between the two latter, however, the passage appears not to be so gradual, on account of the black colour of the metamorphic rock, caused by its very micaceous character along the line of contact, though in some places the two rocks appear like different conditions (textures) of the same magma.

As regards their intrusive character, there is also an inexplicable discrepancy in the behaviour of the upper three and the lowest granite-vein, viz. that if this last vein be considered to have faulted the reef (a supposition all the circumstances certainly point to), no reason can be assigned why the other veins should not have done the same, seeing that they intersect the reef at angles equally favourable for the production of this phenomenon. A shifting of the reef might perhaps have been caused by the second vein; but as, from the mode of intersection (figs. 5 & 5*a*), it would have taken place in the direction of the strike, *i. e.* the surface-portion of the reef moved southward, no displacement might be apparent; with the other two veins, however, it ought to be as plain as with the fourth granite-vein.

The minerals hitherto observed as associated with the gold in the Nuggetty Reef are the following:—

Iron-pyrites. Occurring generally in patches, strings, and, though rarely, in druses of small cubical crystals in hollows.

Arsenical pyrites. Like the former; seldom as perfect crystals imbedded in solid quartz.

Magnetic pyrites. Scattered through the quartz in small patches; not found in crystals as yet.

Copper-pyrites. Like the former, but rather more rare.

Galena. Very abundant, finely disseminated, and in patches; but seldom, and always imperfectly, crystallized.

Zinc-blende. Finely disseminated and in small patches, generally in connexion with galena; not yet observed crystallized.

Maldonite, Bismuthic Gold. Generally in the neighbourhood of the granite-veins, and often a few inches deep in the granite itself, specks of a soft malleable ore occur, having a pinkish silver-white colour, with a brilliant metallic lustre when freshly broken, but tarnishing gradually when exposed to the atmosphere, becoming first of a dull copper-colour, and ultimately quite black. Of this rare ore only a very small quantity has yet been available for blowpipe experiments, by which I determined it to be an alloy of bismuth and gold, and for an assay, made by Mr. Cosmo Newbery, which showed its composition to be 64·5 gold and 35·5 bismuth, agreeing closely with the formula Au^2 Bi. Being, as a natural product, quite new to science, it is proposed to name this alloy "Maldonite" after the locality of its occurrence. It is softer than pure gold, fuses more easily before the blowpipe on charcoal, and, whilst turning to a bright gold bead, imparts to the chacoal the yellow coating of bismuth. It shows no trace of tellurium, sulphur, &c. Cleavage apparently cubical; very sectile. It is no doubt the ore that gave rise to the frequent admixtures of bismuth in the gold of the Nuggetty Reef.

In addition to the different ores just mentioned, which, with the exception of the "Maldonite," appear to increase in quantity beneath the water-level, there occur frequently in the quartz, and not at all confined to the neighbourhood of the granite-veins, irregular patches and imperfect crystals of bluish and greenish-white felspar (oligoclase) and of silvery white and black mica; also, scattered through the reef, narrow veins and small lumps of a white kaolinic clay.

In conclusion, it may not be out of place to remark that the surface-workings on this interesting reef present a glaring instance of misspent labour and capital, due no doubt to the dislike to cooperation, often noticed among the miners in the early times of the Victorian gold-fields. Running up the steep slope of the hill, called Mount Moorul, the main portion of the reef in strike, and considerably over 100 feet in dip, might easily have been worked by one main shaft, in connexion with a tunnel starting from a deep gully that runs alongside the reef. Instead of this, however, at least a dozen costly shafts have been sunk, out of which the quartz had to be raised by windlass or horsewhim, to be directly shot down again by means of shoots to the bottom of the before-mentioned gully, whence it was carted to the crushing-machines in the neighbourhood.

3. *On the* Caratal Gold-field.

By C. Le Neve Foster, B.A., D.Sc., F.G.S.

[Abridged.]

The Caratal goldfield, for our knowledge of which we are indebted to Dr. Plassard, is situated in Venezuela, about 160 miles in a straight line east-south-east of Ciudad Bolivar or Angostura, the capital of the State of Guayana. It lies about 100 miles south of the River Orinoco, about seventy-five miles up from the principal mouth.

Before entering upon a description of the various kinds of gold-deposits, I must give a short general sketch of the geology of the district.

The country between Ciudad Bolivar and Pastora consists almost entirely of gneiss, with some mica-schist and hornblende-schist, and a little granite. All three varieties of rock are seen at Ciudad Bolivar itself. From Ciudad Bolivar to the Caroni there is a gently undulating savannah showing outcrops of gneiss as far as the neighbourhood of the Arasiama ridge, which is formed of itaberite. About Arasiama, and on both sides of the Caroni near Guri, the strike of the gneiss is, roughly speaking, east and west.

Beyond Charapo there is some hornblende-schist striking E. 15° N. in some of the land which forms the watershed between the basin of the Orinoco and that of the Essequibo. Where the road crosses it, the watershed is not more than about 1100 feet above the sea-level.

Further east, at Limones, I saw granite; but the greater part of the country consists of gneiss, which now gets a strike of N. 18° W. to N. 15° E. Both east and west of the Oronato I found hornblendic schist, striking N. 10° E., N. 45° W.

In crossing the Guatapolo I noticed a dyke of porphyrite resembling some of the Cornish elvans, and remarkable for the well-crystallized quartz which it contains.

Before arriving at Pastora the series of schists and slaty rocks, which continue into the Caratal district, make their appearance; near Pastora there are siliceous schists striking N. 45° W., N. 60° W., N. 70° W.; and at Caratal itself these rocks are often a fine-grained clay-slate like some of the Cornish "killas." At other times the rock is much coarser; and a very talcose variety frequently occurs. As a rule, these slaty rocks are much decomposed. The decomposed schist forms the "bed-rock" in many of the alluvial diggings, and is known to the miners as "cascajo." Besides these slaty rocks, there are large outcrops of a felstone; but I cannot say whether it is intrusive or interbedded. This felstone is the "bluestone" of Dr. Stevens *. It is a compact grey, bluish-grey, or greenish-grey rock, often containing small crystals of iron pyrites, the "mica" of the miners. The schistose rocks have, roughly speaking, an east and west strike, with a varying dip.

* 'Scientific American,' 25th Nov. 1868, and 'American Journal of Mining,' 1st Aug. 1868.

It was only on the north side of the Yuruari, near the Tupuquen Ford and north of Callao, that I noticed outcrops of a rock which I have called "gabbro" on the authority of Mr. David Forbes, F.R.S.

To the north of the mining district—in fact, in the country about Upata, gneiss, mica-schist, hornblende-schist, and granite occur; but time did not permit my making any full examination of this part. It will thus be seen that to the west and north the gold-bearing slates are surrounded by gneiss and other metamorphic rocks. No fossils have as yet been found, though carefully searched for by Dr. Plassard ever since he discovered the gold-fields. The age of the rocks is consequently unknown.

I will now pass on to the gold deposits of the Caratal district.

These may be classed under four heads:—1. Lodes, veins, "reefs," or "ledges," *filones*; 2. Alluvial or "placer" diggings, or *greda*; 3. Red earth, or *tierra de flor*; 4. Gravel and sand of river-beds.

1. *Lodes.*—About a dozen lodes have been discovered and worked on. It is impossible to give any general direction of the strike and dip of these lodes; but it may be remarked that several well-marked and rich lodes run east and west, while others, equally productive, have strikes approaching to north and south.

As the lodes are few in number, a short description of each will furnish the easiest method of giving an idea of their general nature.

The Callao lode lies about a mile and three-quarters N.N.W. of Nueva Providencia. It is a north and south lode dipping west, and is from 1 foot to 2 feet thick in many places; it consists mainly of quartz with a little iron-pyrites and brown oxide of iron, &c., and a few blackish streaks due, perhaps, to chlorite. The gold in this lode is very coarse, and specimens of pure white quartz and native gold, without a particle of oxide of iron, are often found. The surrounding rock or "country," is felstone, with a little iron pyrites. The miners say that the presence of iron pyrites is a favourable sign for the productiveness of the lode. The Callao lode has been worked along the strike for a distance of about 200 yards, and it is said to die out southwards. The deepest workings in the Caratal district are upon this lode; but they only reach down 36 yards, further progress being prevented by water and the want of pumping-machinery. Very large quantities of gold (I believe I am under the mark in saying 1000 oz. per month) have been obtained from Callao.

The Corinna lode is situated further eastward, on the bank of the Yuruari. The lode is 4 feet wide in places, and dips west. It consists mainly of quartz, with brown oxide of iron, mammillated pyrolusite, thin streaks of a blackish mineral, and visible gold. This lode has been worked to a depth of about a dozen yards and has been profitable.

In the neighbourhood of the Corinna the American Company has made openings upon other lodes and branches. Some of the quartz shows visible gold, the rest does not; but all is auriferous; on an average, I am told that the quartz from these openings gives about 1½ oz. of gold to the ton. The "country" of these lodes and of the Corinna consists of decomposed schist. On the hill south-east of Nueva Providencia there are numerous abandoned "barrancos" or pits sunk to work the Tigre lode. I was told that its strike is N. 30° E., and that it is about a foot wide and very rich. The country is a hard, dark-greenish rock.

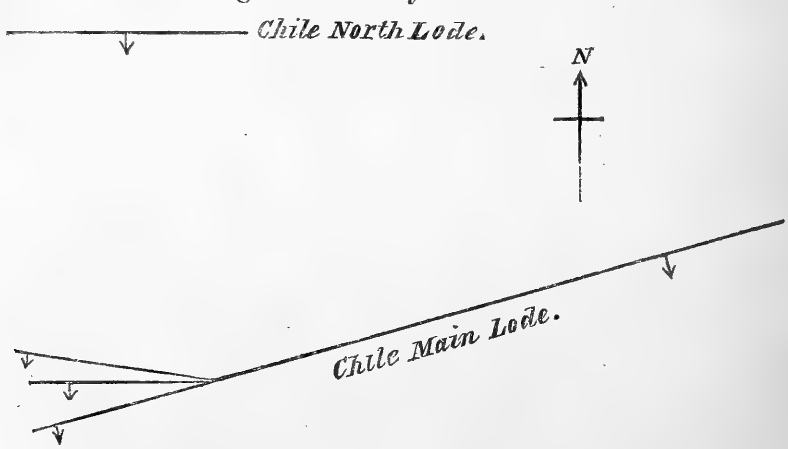
In Nueva Providencia numerous blocks of loose quartz containing gold are lying about in one part of the town, probably derived from a lode which crops out here, and the Prefect of the Department of the Yuruari has been working a lode in his garden just east of the town. In the San Felipe property, to the south of the town, several lodes are said to have been discovered.

The Peru lode, situated near the source of a branch of the Mucupia brook, runs E. 5° N. and dips south at 60°. It is 2 feet wide, and consists of quartz, with brown oxide of iron, the usual blackish streaks, talc, and visible gold.

In another little, neighbouring valley are the Potosi workings. In one of the adits driven into the hillside there are two east and west lodes, dipping 55° in opposite directions, the level being driven just below the intersection. The stuff is very similar to that of Peru, and there is no difficulty in finding visible gold.

The Chile lode lies about a quarter of a mile south of Potosi, and, after Callao, is at present the most important in the Caratal district. The *Chile main lode* runs about E. 10° N. to E. 15° N., and dips south at 45° to 60°. It varies in width from 2 feet to 6 feet. It consists mainly of quartz, with brown oxide of iron, the blackish streaks, talc, a white earthy mineral like kaolin, and visible gold. In many pieces of stuff from this lode there are cubical cavities lined with gold as if they had been plated, or containing leafy gold; sometimes also the cavity is filled with brown oxide of iron in which specks of gold are visible. The cavities seem to be due to the decomposition of iron pyrites which originally filled them. The coarse gold which is found at Callao does not occur at

Fig. 1.—*Plan of Chile Lodes.*

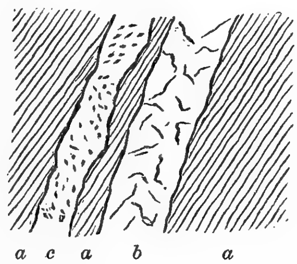


Chile. To the west the Chile lode splits up into at least three branches, as is shown on the accompanying diagram-plan (fig. 1).

Here I have also shown a lode to the north which was exceedingly rich. The north lode is like the main one in having the greater part of the gold in cavities in the quartz partly filled with brown oxide of iron.

The Chile main lode has been worked to a depth of about 30 yards. The "country" is decomposed talcose clay-slate. In several of the shafts which have been made on this lode, the "porfiro" or "porfido" of the miners occurs. This so-called "porphyry," also known at Chile as "quartzo morado," and "piedra morada," is a reddish, pink, or brown ferruginous hornstone, sometimes becoming jasper. It sometimes contains crystals of iron pyrites, or cavities left by their decomposition. At Chile, as shown in fig. 2, it forms a sort of lode parallel to the white quartz lode, from which it is separated by a few inches of "cascajo." The Chile miners told me that they occasionally found visible gold in it, but too little to pay them to work it. A similar rock ("porfiro") is found all over the Caratal district and is regarded by the miners as a favourable indication for gold.

Fig. 2.—*Section of Quartz and "Porphyry" Lodes.*



a. "Cascajo," decomposed clay-slate. *b.* Quartz lode. *c.* So-called "porphyry."

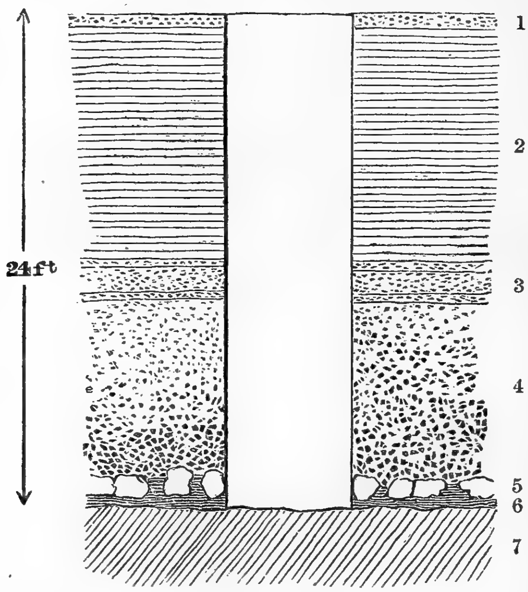
A little work has been done on a lode called San Antonio, a short distance from Chile. Two "barrancos," very close to one another, have been sunk upon it, and they show a quartz lode 2 feet thick, which strikes from S. 20° E. to S. 45° E., and dips sharply to the west. The surrounding rock is "cascajo." The lode consists of quartz, with black streaks, iron pyrites, brown oxide of iron, and very fine gold.

Lying in the basin of the Yguana, like Chile and San Antonio, are the Panama workings. Much work has been done here upon loose blocks of quartz which strew the hillside, and a small opening has been made on the top of the hill upon an east and west lode. This lode is 3 feet wide in places, and dips south. On the opposite side of the valley a flattish lode 2 to 6 feet thick has furnished a good deal of quartz. Quartz has also been found and worked at the Lagunta, near Panama, and at the Independiente, between Panama and Nueva Providencia.

2. *Alluvial or "placer" Diggings.*—Excepting a few places on the banks of the Yuruari, the working of auriferous alluvia has at present been confined to the valley of the Mucupia and its various tributaries, such as the "quebradas," or valleys, known as the Tigre, Peru, Aguinaldo, &c.

On leaving Nueva Providencia by any of the paths to the west, we come upon pit after pit 6 to 10 yards deep; and although this ground was worked as early as 1857 and 1858, it can be pretty well seen what the diggings were like. The accompanying section (fig. 3) is made up partly from personal observation and partly from information obtained from Dr. Plassard, who was at Caratal while this stuff was being worked.

Fig. 3.—*Section of Alluvial Digging near Nueva Providencia.*



The following is the succession of the beds :—

1. Soil.
2. Red clay, showing no signs of stratification.
3. Soft clayey "moco de hierro."
4. Hard "moco de hierro," brown iron ore, with pieces of quartz in it and a little clay.
5. Blocks of vein-quartz, often auriferous.
6. "Greda," or pay-dirt, a yellow ferruginous clay containing nuggets and small grains of gold.
7. "Cascajo," decomposed schist, forming the "bed-rock."

About half a mile from the town, on the road to Tupuquen, are the "Planada" diggings, said to have been worked with much profit in 1857. The section of one of the Planadà pits is as follows:—

1. Soil.
2. Clayey gravel.
3. Blocks of quartz.
4. "Greda," or pay-dirt.
5. "Cascajo," the bed-rock.

In a neighbouring pit I saw about 6 feet of clay and then 6 feet of gravel, the bottom being filled with rubbish. The pebbles found in the gravel are mainly composed of the greenish grey felstone, known as "piedra negra;" subangular and rounded pieces of ferruginous hornstone are also common. Higher up the valleys the placer diggings are shallower.

3. *Tierra de Flor and Moco de Hierro.*—In many places in the Caratal district, just below the soil, at a depth of 18 inches to 3 feet,

there is a layer of red earth, often containing pieces of auriferous vein-quartz, pieces of "moco de hierro" and grains of pisolitic brown hæmatite, the "granson" of the miners. When washed, this "tierra de flor," or "surface earth," as it is called, furnishes, in addition, decomposed crystals of iron pyrites, a black magnetic iron sand called "arenilla," and often nuggets of gold. The manner in which the gold occurs appears to be very irregular; the miner may wash "batea" after "batea" of earth and find no gold, or only the "color de oro" (*i. e.* merely a few fine grains of gold), and then get several nuggets in the next lot. The largest nugget yet found in the Caratal district was obtained from the "tierra de flor," close to Nueva Providencia; it weighed 15 lbs.

In the diggings at the south-south-west corner of the town I saw "tierra de flor" lying above alluvial ground.

The following is the succession:—

1. Soil.
2. "Tierra de flor," red earth, with loose stones of quartz.
3. Ferruginous clay.
4. "Greda," or pay-dirt, yellowish clay, with blocks of quartz.
5. "Cascajo," or bed-rock, decomposed schist.

From the manner in which this "tierra de flor" occurred, I at once concluded that, geologically speaking, it was a "rainwash;" but it was some time before I understood whence it was immediately derived. At last, after talking the matter over very frequently, Dr. Plassard and I arrived at the conclusion that the "tierra de flor" is nothing more or less than decomposed "moco de hierro" washed down the hillsides.

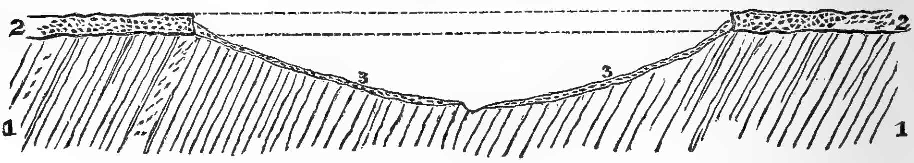
The name "moco de hierro" is given to a highly ferruginous, rock, which assumes the various forms of:—

a. Ferruginous conglomerate.
b. Ferruginous grit.
c. Ferruginous breccia.
d. Pisolitic brown iron-ore.

It always consists mainly of limonite and earthy red hæmatite, with pebbles or angular and subangular fragments of quartz, schist, and felstone. When it takes the form of pisolitic brown iron-ore, it consists of a number of globular concretions of limonite. This "moco" is found in loose blocks on the surface, and often forms plateaux, sometimes more than a hundred (or even two hundred) acres in extent. The edge of the plateau is generally marked by a bold rocky escarpment. Here it may be seen that the "moco" is 6, 8, or even 10 feet thick at the least; and the same thing may be observed where a stream has cut its way down through a "moco" plateau as shown in fig. 4.

In searching for quartz-lodes I came to the conclusion that the "moco de hierro" affords no evidence of lodes in the immediate vicinity; for my observations led me to infer that it is probably of alluvial origin. I should suppose that the ferruginous matter of which it consists so largely is derived from iron pyrites, which was contained in the alluvial deposit, partly in the form of loose pieces and partly enclosed in fragments of rock. Some may also have

Fig. 4.—*Valley-section, showing the Formation of "Tierra de flor" from "Moco de hierro."*



1. "Cascajo," or felstone. 2. "Moco de hierro." 3. "Tierra de flor."

been derived from chalybeate waters coming from other sources than the alluvium itself. In some cases, the "moco" is of undoubted alluvial origin; and the miners, finding that where they met with a bed of "moco" they usually had a good pay-dirt, or "greda," came to the conclusion that the "moco" was a good indication of gold deposits of all sorts. I must further add that the alluvial "moco" lying above the pay-dirt has occasionally furnished nuggets covered with a black coating of oxide of iron, like some that are found in the "tierra de flor."

From all this it will be seen that there is nothing in the mode of occurrence or mineral contents of the "tierra de flor" to militate against the hypothesis that it is neither more nor less than "moco" decomposed in place, or decomposed "moco" washed down the hillsides.

Should all the "moco" be of alluvial origin, we may expect a pay-dirt below it in the higher plateaux, just as we find one in the more recent deposits; and it is possible that the nuggets in the red dirt are mainly derived from a pay-dirt underlying the "moco," and not from the "moco" itself.

Some assays of "moco" that I made at Caratal gave gold; some that have been made since gave either no gold or merely traces. There are therefore two points which remain to be settled with regard to the "moco":—

(1) Whether it often contains gold enough to make it a workable deposit.

(2) Whether all "moco" is really a deposit like the "moco" of the "placer" diggings near the town, or, in other words, whether it overlies a pay-dirt or deposit of alluvial gold.

4. *Recent Stream-beds.*—When the dry season commences, the rivers and streams sink rapidly; many dry up entirely; others still have a few waterholes left; while the Yuruari always flows a little, except in seasons of most extraordinary drought. In any case, banks of sand and gravel are left high and dry, or partially so. On digging through them, a gold-bearing bed is often met with, which furnishes nuggets and small grains of gold on washing. The amount of work which goes on with these deposits at the present time is but small, though at first they were the only ones that were known.

I now come to the question of annual produce. Mr. Mathison, acting British Vice-Consul at Ciudad Bolivar, has kindly furnished me with the following statement concerning the gold produce of the Caratal district:—

1866	15,587 oz.
1867	30,142 oz.
9 months of 1868	22,481 oz.

These numbers represent the quantities shipped by the Ciudad Bolivar merchants *; and all this gold has been produced from the alluvial diggings, the "tierra de flor," and gold quartz crushed by hand in mortars. I should say that at the present time the gold obtained from lodes by far exceeds in quantity that obtained from other sources.

The whole of the present workings are comprised within a circle of 3½ miles radius, with Nueva Providencia as its centre; but it must not for a moment be imagined that this is the whole of the auriferous region. Two American gentlemen, Messrs. Davis and Austen, found gold on the river Paragua; and just before leaving I heard of the discovery of a lode of gold-quartz in the hills to the south of Pastora. A little gold has been found at Upata. Dr. Plassard also tells me that a lode of auriferous quartz traverses the bed of the Yuruari at Cura; and I have heard the same report from Señor Carlos Siegert. It is further known that gold has been found, and even worked on the banks of the Cuyuni in British Guiana. All these facts tend to prove that the auriferous rocks are spread over a very considerable area indeed.

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4. *Notes on the* Geology *of* Guyana, *in* Venezuela. By Ralph Tate, Assoc. Linn. Soc., F.G.S. &c.

I. Introduction.—The observations on which this notice is based were made during a trip of some two months' extent in the latter part of last year, and though having reference to a small section of the province of Guyana, in Venezuela, yet are applicable to an extensive area. The leading geological features are presented in a line of section from the Orinoco, proceeding in a southerly direction; my examination extended to the newly discovered auriferous district of Caratal, distant about 140 miles in a right line from Las Tablas, on the Orinoco.

A few words in elucidation of the physical features of the country, will assist the reader in tracing out the leading geological characteristics of Guyana.

Skirting the Orinoco are the *Llanos*; these, as elsewhere, are characterized by a growth of coarse grass, *Cyperaceæ*, and shrubby trees, the chief of which, and often the only species, is the *chaparro* (*Curtella Americana*); the soil is of the poorest description, being a loose sand, highly absorbent and of great heat-radiating power.

* The amount in 1866 by no means represents the entire quantity obtained, as a great deal was then smuggled to avoid an export duty of 10 per cent. In 1868 the working of the Callao mine was impeded by water.

At the distance of fifteen miles or so from the river, the land rises into scarped, low, more or less wooded heights, constituting the *serranos*, interspersed with grassy slopes and plains. These serranos by easy gradations lead us on to the range of the Itacama Mountains, which trend east and west and attain an elevation of about 3000 feet. The range occupies a breadth of about sixty miles; and its southern slope is bounded by an undulating grassy plain presenting an aspect similar to that of the *Llanos*, excepting that woodlands occupy the margins of the streams, and that a species of palm grows on the moister portions of the soil. This plain, the mean elevation of which is about 800 feet above the sea-level, stretches southward as far as the river Yuruari, which marks off the savannah from the forest-region of the Caratal, the subsoil of which is a ferruginous clay affording firm attachment for timber trees of large growth. The Caratal district, so far as it is known, is broken up into ridges and peaks of about 1500–2000 feet elevation, with narrow and deep dividing valleys.

It is to be observed that the Itacama Mountains divide the eastern part of Venezuelan Guyana into two hydrographical basins, to the north that of the Orinoco, and to the south that of the Essequibo, which by its tributary, the Cuyuni, and its numerous affluents drains the country to the south of the Itacama range, and to the east of the basin of the Caroni.

II. Geology of North-east Venezuela.—Mr. Wall*, in his "Geology of a Part of Venezuela," has described the geological features of a portion of Venezuela to the north of the Orinoco; and, so far as I can judge by reading his account, the arrangement and nature of the rocks in the district to the south of the river seem to concur in a great measure with those to the north.

That author has established the existence:—First, of a series of micaceous and siliceous schists, with interbedded crystalline limestones; and in a few restricted localities the schistose beds alternate with gneiss. This group of metamorphic rocks, to which he has assigned the term Caribbean, exhibits great disturbance and contortion; the strike is ordinarily east and west; the metalliferous minerals are gold *disseminated* in gneiss west of Valencia, a sulphuret and carbonate of copper in the schists at Las Teques, near Caracas, and argentiferous galena near Carupano. Secondly, of neocomian strata overlying the schistose rocks to the south; and, thirdly, of an arenaceous series belonging to the upper miocene, and termed newer Parian by the author, which overlies and abuts against the neocomian rocks. In Venezuelan Guyana, the metamorphic series and the upper miocene strata are developed, but neocomian beds have not been observed.

III. Metamorphic Series of Venezuelan Guyana.—The section attached (fig. 1) will suffice to show the regularity of the bedding, and the somewhat undisturbed conditions, of this series. The trend is usually east and west, and coincides with that of the Caribbean system of Northern Venezuela; the dip is from 70°–75°, to the north ordinarily;

* Quart. Journ. Geol. Soc. vol. xvi. p. 460 *et seq.*

the thickness is very considerable, and the area undoubtedly great. The dip and strike of the rocks are given with reference to the magnetic meridian. The sequence of the various rocks can be made out with tolerable precision; on the whole the felspar predominates in the lower strata, whilst hornblende and mica increase in quantity as we rise in the series*.

1. *Felstone and Talcose Schists.*—To the extreme south of the line of section, and beyond the river Yuruari, is situated the Caratal gold-field, which until the last ten years remained hidden in the solitude of the virgin forest. The auriferous veins are included chiefly in a felstone, "piedra azul" of the miners, and also in a talcose schist. From the usual mode of association of auriferous veins with diorites in Central America and Bolivia, I was led at first to regard the chief auriferous rock of the Caratal gold-field as a diorite in which the hornblendic constituent was wanting; but its immediate association with the talc-schist, and its conformity with the metamorphic series of the country, have finally induced me to view it as constituting a part thereof. Unfortunately, the absence of sections has prevented my satisfying myself on this point; but one section on the Rio Mucupio exhibits the talc-schists overlying the felstone, dipping together to the north at from 60°–70°, and striking west 30° north: there are no evidences of alteration along the line of junction; and elsewhere the talcose rock appears incorporated with the felstone.

The felstone is homogeneous, of close texture, and usually semi-columnar; but where it constitutes the vein-stone of the Tigre and Santa-Maria lodes, it contains isolated quartz-crystals and chlorite. To the south-west of Nueva Providencia and high up on the river Yguana the strike approaches north and south, and the dip is 85°–90° westerly.

2. *Caratal Gold-field.*—The auriferous area at present known is about twelve square miles, the whole of which is traversed by gold-bearing quartz-veins, averaging in thickness from 2–3 feet, most of which have yielded visible gold in abundance. The richness of some of the lodes, and of the "placer" diggings of this auriferous tract, fully justifies the appellation of "El Dorado" which has been given to it; and it may be the "El Dorado" that incited Raleigh to penetrate Venezuela, but which he failed to discover.

The veins present little conformity as regards their strike; but many apparently trend about N.E. and S.W.; the dip varies from 45°–90°. I have obtained gold in the felstone and talc-slates, in the vicinity of the auriferous lodes; but it has not occurred to me disseminated in the main masses of these rocks. Great diversity in the character of the quartz prevails, so much so that specimens from the various lodes can in the majority of cases be readily identified, as, for instance, that of the Callao lode is highly vitreous, with the gold more or less lamelliform and arborescent; that of the Potosí lode is saccharoid, with finely disseminated gold, and granular gold localized in the parallel strings of hæmatite, which also are rich in

* [Specimens of rocks and minerals, in illustration of this paper, have been presented by the Author to the Society.—Edit.]

sulphuret of silver; that of the Corinna lode is largely mixed with psilomelane, whilst that of the Tigre lode is a jaspery quartz highly charged with auriferous iron-pyrites. The accompanying metalliferous minerals observed are few in number: hæmatite, red and brown, psilomelane, sulphuret of silver, and iron-pyrites are of frequent occurrence, whilst cinnabar, galena, and carbonate of copper have been found only as isolated specimens.

3. *Quartzites, Gneissic and Hornblendic Rocks.*—Passing to the north, the felstone is bounded by a band of jaspery quartzite; it is traceable from the west of Callao, along the margin of the Yuruari, to below the Tupuquen ford, a distance of about three miles; the quartzite resembles a jaspery quartz that is met with in several of the auriferous lodes, but it differs in the absence of iron-pyrites, and in its more saccharoid texture; and as its trend conforms to that of the rocks to the north and south, it must be regarded as one of those masses of quartzites which alternate with the gneissic rocks to the north.

From the river Yuruari to the river Orinoco, the strata exhibited are a great breadth of gneiss and gneissoid rocks, and narrower bands of hornblende-slate and quartzite. To the south of the town of Guasipati, blocks of quartzite are scattered about upon an argillaceous surface, undoubtedly resulting from the decomposition of gneiss in place; this quartzite is semicrystalline and micaceous. Again, some fifteen miles to the north of Guasipati, as near the rancho of Platanal, the savannah presents the appearance of a vast cemetery from the varied masses of a semivitreous quartzite; and as similar masses occur to the west, they indicate a band of quartzite two or three miles in breadth coursing about east and west. But in the neighbourhood of Upata, the quartz blocks which strew the undulating ground are largely caverned by casts of iron-pyrites, and are probably of vein-origin.

The gneiss with its interstratified quartzite extends from the river Yuruari, to near the rancho of San José, where a narrow strip of amphibole-schist appears, striking east and west, and dipping to the north; a narrow band of gneiss separates it from a similar rock which extends from the rancho of Santa Anna, to the north of that of Candelaria, a distance of about twelve miles; in the bed of the river Carichapo, near Candelaria, this rock strikes east and west with a dip to the south of about 85°; it here encloses non-auriferous quartz-veins.

Before reaching the ford of the Carichapo, north of Candelaria, gneiss appears, and continues with some variation in its constituent minerals to the banks of the Orinoco. At Upata the prevailing variety is a porphyritic felstone, succeeded to the north by a true gneiss, in which the foliation is obscure, but, when viewed on an extensive scale, is generally that of the strike of the beds, which was ascertained to be west 15° north; in some instances the foliation was south-west and north-east. To the north of the rancho of Guacaima and nearer to the Orinoco, the mica of the gneiss is replaced by hornblende; and near Las Tablas, and around Bolivar, the

Fig. 1.—*Section from the Orinoco at Las Tablas to Caratal.* (Distance about 130 miles. Vertical scale $\frac{1}{4}$ inch to 3000 feet.)

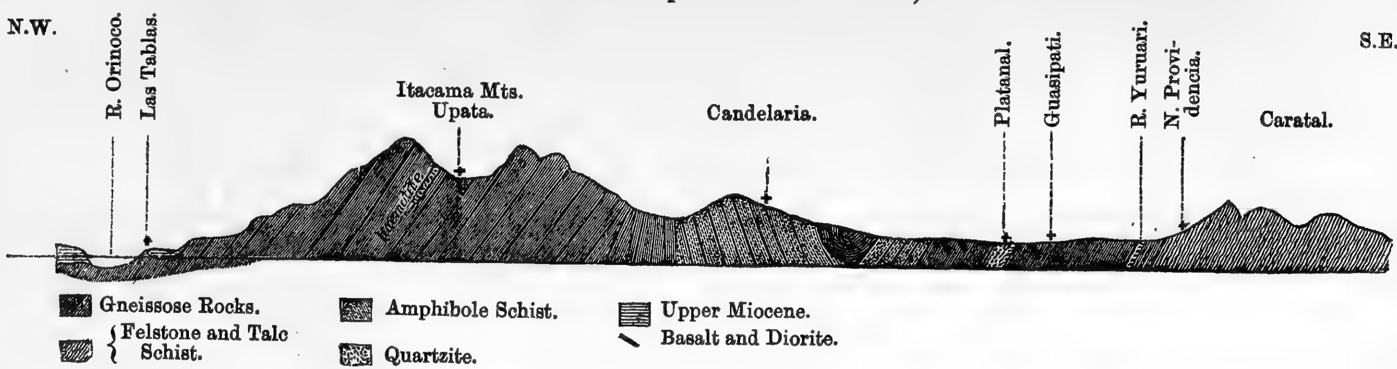
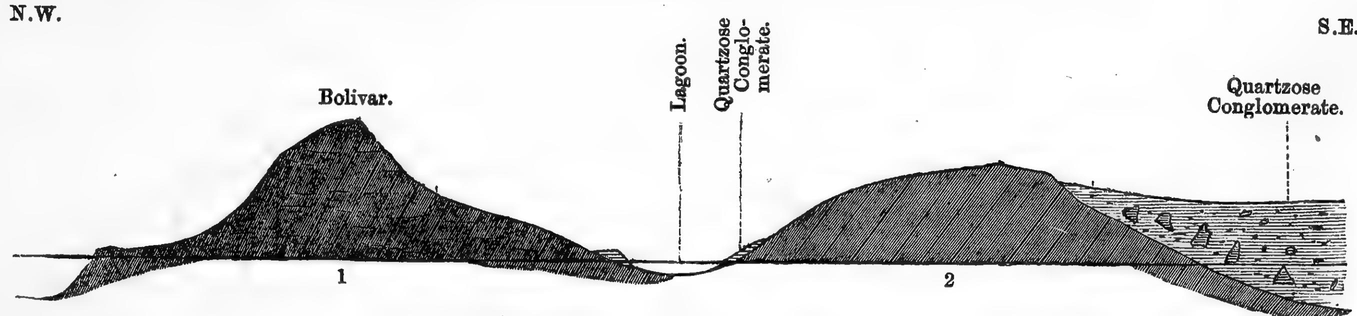


Fig. 2.—*Section from Bolivar to San Isidore.* (Distance about $1\frac{1}{2}$ mile.)



1. Hornblende Rock. 2. Gneiss.

gneiss is granitoid. Skirting both banks of the Orinoco, and lying beyond the granitoid gneiss are hummocky protuberances of hornblende rock, highly crystalline, and containing garnets; the rock is jointed by partition planes, having a north and south bearing, and is in part further broken up into rhomboidal masses.

There is great presumptive evidence that these gneissic rocks, as well as those of northern Venezuela, contain disseminated gold, as the sands of most of the streams flowing from the Itacama mountains have yielded gold in a fine state of division; the stratified débris of these rocks, at San Isidore, show on assay as much as $4\frac{1}{2}$ ounces of gold per ton*. The region occupied by the gneiss is comparatively easy of exploration, and has been well prospected for gold-veins, but up to the present time without success.

The gneiss, three miles to the north of Upata, contains a rich deposit of red hæmatite; this was observed on the slopes of two hills, about two miles apart, and it is highly probable that the ferruginous mass is interstratified with the gneiss. Mr. Siegert, a local surveyor, has discovered in this neighbourhood evidences of ancient metallurgical operations for the reduction of silver.

4. *Conjectures as to the Age of the Auriferous Series.*—From the known distribution of gold in the rocks of the American continent, speculations as to the relative age of the auriferous rocks of Venezuelan Guyana will be necessarily directed to the Silurian and Oolitic strata. But as the Oolitic rocks are only auriferous by the intrusion of certain diorites, and as such do not appear to have played any part in the development of gold in the rocks of the district under consideration, there remains but the inquiry into the evidences of their being of Silurian age. The metamorphic series of Northern Venezuela, which I regard as contemporaneous with that of Guyana, is overlain by unmetamorphosed Neocomian strata; but as "the relations of junction of the two formations remain obscure"†, we have no certain data as to their age, except that they are precretaceous. Mr. David Forbes‡ has determined that the eminently auriferous rocks of Bolivia belong to the Silurian system; and though consisting chiefly of clay-slate, shales, and grauwackes, yet this author refers the gneissic and metamorphic schistose rocks in the desert of Atacama to the same series. The mineral contents of the auriferous rocks of Guyana have not been sufficiently ascertained to afford data for the determination of the age of the rocks by analogy of the mineralogical features. And though the contemporaneity of these auriferous metamorphic rocks with those of Bolivia has not been proven, yet the balance of evidence is in favour of such association, rather than with the Oolitic series of the same country.

IV. Intrusive Rocks.—Narrow dykes of basalt were noticed traversing the gneiss, between the rancho of Santa Anna and Guasipati; and blocks of greenstone were observed, but not *in situ*, at Upata.

V. Stratified Detrital Deposits of the Llanos.—The arenaceous

* El Boletin Comercial: Bolivar, March 1867.

† Wall, *loc. cit.* p. 465.

‡ Quart. Journ. Geol. Soc. vol. xvii. p. 53 *et seqq.*

series skirting the Orinoco, and abutting against the northern escarpment of the Itacama range of mountains is indubitably an extension of the Newer Parian of Mr. Wall, which occupies the grassy plains to the north of the river. In the neighbourhood of Bolivar its rocks rest against the metamorphic boss on which the city stands, and consist of a yellow sand-rock below, passing upwards into a red sandstone, which in places is highly ferruginous; surmounting the latter is a quartose conglomerate in an iron-stone paste; the pebbles are of the size of marbles and are well water-worn. The whole of this series stretches far away in every direction from Bolivar, and has a slight dip to the north. The broad valley of San Rafael with its low mural cliffs of from thirty to fifty feet in height is excavated in the yellow sand-rock; and the same series of strata forms the banks of the Orinoco. No fossils were observed in the sandstone beds; but elongated cavities within the sand-rock appear to have been occupied by fragments of the stems or roots of plants.

That these arenaceous strata have originated from the wear and tear of the metamorphic rocks is satisfactorily proved by sections exhibiting the relation between the two series (see fig. 2).

Resting on the granitoid gneiss is a loose ferruginous conglomerate containing large blocks of angular quartz, fragments of mica-slate, &c., the constituents becoming finer and rounder as they are traced from the insular mass around which they have been collected.

Alluding to the probable origin of the Pitch lake, of Trinidad, Sir Charles Lyell*, quoting Dr. Nugent, writes that "the Orinoco has for ages been rolling down great quantities of woody and vegetable bodies into the surrounding sea, where, by the influence of currents and eddies they may be arrested and accumulated in particular places . . . . , and that these vegetable substances may have undergone those transformations and chemical changes which produce petroleum." My observations do not confirm the speculation put forth by this author as to the part played by the Orinoco. The identity of the arenaceous strata of the Llanos of the Orinoco, which in places are also lignitiferous and asphaltitic, with the similar strata of the Moruga and Caroni series in Trinidad may be considered certain; and as the bed of the Orinoco, from Ciudad Bolivar (certainly so far west) to the apex of the delta, is excavated in these same strata, it is quite clear that the present river-valley is of more recent origin than those beds to the accumulation of which, in the paragraph quoted, it is implied the river has contributed.

From the absence of fossils, other than vegetable remains, in the Llanos-sandstones, and the presence of marine shells at Cumana and in Trinidad, it appears highly probable that the arenaceous series of the Llanos have been deposited in a shallow estuary, whilst the present littoral areas of the same series have been accumulated under marine conditions.

VI. Superficial accumulations of Limonite.—A striking feature of the surface of much of the country passed under review, is the presence of a hydrous oxide of iron—the *moco de hierro* of the

* Principles of Geology, 9th edit. p. 250.

miners. In the mining district it is in the form of vesicular masses, of one or two cubic feet contents as a maximum. It frequently cements fragments of vein-quartz to form a breccia; and small nuggets of gold are not unfrequently found imbedded in it: even when occurring dissociated from these masses, they are more or less coated with the mineral. On the gneissic surface the ferruginous agglomerations do not exceed the size of an orange, and usually enclose rounded pebbles. The origin of this mineral is to be sought for in the decomposition of the iron-pyrites of the lodes and that of the ferruginous minerals that enter into the composition of the metamorphic rocks. The *limonite* abounds on the north slope of the ridge, carrying the Tigre lode, and in parts of the Potosí estate, in which instances they are in proximity to pyritous lodes. On the gneissic area they are more abundant between Guacaima and Upata, where the gneiss is hornblendic. The greater abundance of this mineral in the mining-district is to be ascribed to the relatively larger store of iron in the rocks constituting this tract.

VII. Supplemental Notes on the Geology of North-west Venezuela.—My friend, F. Mathews, Esq., C.E., has presented to the Society a series of minerals and rock-specimens from the province of Cora, from which we learn that the cupriferous veins of Aroa, near San Felipe, are contained in a mica slate, which is probably an extension of the metamorphic series of Valencia described by Mr. Wall. Specimens of lignite and brown coal point to the existence of the Upper Miocene in the province of Cora. And this gentleman has noted the occurrence of a shell-bed at Tucacas, extending three miles inland, and attaining an elevation of 30 feet. The shells are species of *Tellina*, *Cardium*, *Venus*, &c., and are identical with those of the present beach.

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5. *On the* Nature *and* Cause *of the* Glacial Climate.

By Joseph John Murphy, Esq., F.G.S.

In the present paper I purpose to show how far I agree with, and where I differ from, Mr. Croll as to the views on the cause of the glacial climate set forth in his paper in the 'Philosophical Magazine' for August 1864.

Mr. Croll's conclusions may be stated in the three following propositions:—

1. A glacial period occurs when the excentricity of the earth's orbit is at a maximum, and the solstices fall when the earth is in perihelio and in aphelio.

2. Only one hemisphere, the northern or the southern, has a glacial climate at the same time.

3. The glaciated hemisphere is that of which the *winter* occurs in aphelio.

I agree with Mr. Croll as to the first two propositions, but differ as to the third. I believe that the glaciated hemisphere is that of which the *summer* occurs in aphelio.

The following propositions are self-evident when stated:—

When the excentricity of the earth's orbit is very considerable, and the winter of either hemisphere occurs in perihelio and its summer in aphelio, the nearness of the sun in winter will cause a mild winter, and his remoteness in summer will cause a cool summer.

Conversely, in the opposite hemisphere at the same time, the winter will occur in aphelio and the summer in perihelio: the remoteness of the sun in winter will cause a cold winter, and his nearness in summer will cause a hot summer.

Suppose, for instance, that when the excentricity of the earth's orbit is much greater than at present, the midwinter of the Northern hemisphere occurs in perihelio: then

the *Northern* hemisphere will have a *mild winter* and *cool summer*,
the *Southern* hemisphere will have a *cold winter* and *hot summer*.

So far (granting Mr. Croll's astronomical data, for which he cites Leverrier, and which I believe are indisputable) there is no room for doubt. I have now to discuss the question, what effect these diversities of climate will have in producing glaciation.

Mr. Croll thinks the hemisphere of *cold winter* will be the glaciated one. I think, on the contrary, the hemisphere of *cool summer* will be the glaciated one.

On this subject it is needless to attempt to make any deductions from theory. We have plenty of observed data; and I think I can show that they all go to prove a cool summer to be what most promotes glaciation, while a cold winter has, usually, no effect on it whatever.

Forbes, in his work on Norway and its Glaciers, p. 206, quotes "the excellent generalization of von Buch, that it is the temperature of the summer months which determines the plane of perpetual snow." This indeed is almost an identical proposition; for perpetual snow is snow that lies through the heats of summer; and it would appear obvious enough, had it not been frequently overlooked, that it must be the temperature of summer which, other things being equal, determines the level of summer snow.

But, according to the same authority (Forbes's 'Norway and its Glaciers,' p. 206), "another cause affecting exceedingly the level of the snow-line is the amount of snow which falls."

These laws are illustrated in detail by the following table. In constructing it I have assumed, what is tolerably near the truth, that the temperature of the hottest month of the year decreases in ascending at the rate of 1° F. for every 300 feet. The temperatures are taken, as accurately as I have been able to do it, from Dove's map. My authorities for the heights of the snow-line are, for the first four, Durocher as quoted by Mr. Hopkins in the 'Proceedings of the Geological Society' for Dec. 17, 1851, for the rest, Mrs. Somerville's 'Physical Geography,' p. 314. The temperatures are in degrees of Fahrenheit. The heights are in feet.

	Temperature of hottest month at sea level.	Height of 32° F. in hottest month.	Height of snow-line.
Pyrenees	74·5	12750	9300
Caucasus	77	13500	10300
Mont Blanc	72·5	12150	9000
Bernese Alps	72·5	12150	8800
Scandinavian Fjelde 61°43′ N.	59	8100	5500
Mageroe, Norway, extreme north	45·5	4050	2160
Himalaya, about 31° N., *north side*	83·75	15525	16620
The same, „ *south side*	83·75	15525	12980
Andes, near Quito	79·25	14175	15795
do. 18° N.	81·5	14850	14772
do. near Valparaiso	68	10800	12780
do. 37° 40′ S.	63·5	9450	7960
Straits of Magellan	45·5	4050	3390

It is evident by this table that the snow-line rises above the line of 32° for the hottest month of the year where the snow-fall is small, and sinks below it where the snow-fall is great. In the Caucasus, the Alps, and the Pyrenees, the snow-line is about three-fourths of the height of the line of 32° for the hottest month of the year; in the Fjelde of Norway, about two-thirds; in the Peruvian and Chilian Andes above, but in Patagonia and Tierra del Fuego below; above, on the north side of the Himalaya, but below on the south side. These contrasts are all to be explained by the difference in the amount of snow-fall, which is greater on the south than on the north side of the Himalaya, greater in Patagonia and Tierra del Fuego than in Chilé and Peru, and probably greater, at least in winter, in Norway than in Central, Southern, or Eastern Europe.

The dependence of the height of the snow-line on summer temperature and on amount of snow-fall, to the exclusion of winter temperature, may be best shown, perhaps, by two extreme cases. The mean temperature of the Altai mountains (according to Mr. Hopkins's paper cited above) is below freezing; yet, in consequence of the comparatively warm summer, and the small snow-fall, the height of the snow-line (Mrs. Somerville's 'Physical Geography,' p. 61) is about 6000 feet. On the Straits of Magellan, on the contrary, though the mean temperature is several degrees above freezing, the height of the snow-line (see table) is little more than half as much.

It is well known that, other things being equal, the magnitude of glaciers depends on that of the snow-fields in which they rise; and as of course any depression of the snow-line will enlarge the snow-field, it follows that the lower the snow-line the further will the glaciers descend below it. As a decrease of about 3° F. is due to every 1000 feet of ascent in the hottest month, it follows that a fall of temperature to that extent in the hottest month would lower the snow-line by about 1000 feet; and in many cases it is likely that the glaciers in such a case would descend 1000 feet further below the snow-line than at present, thus gaining a total increase of 2000 feet of descent. This might not have much effect on the climate of Central Europe, but it would have a very great effect in those high latitudes where the glaciers would reach the sea and give origin to icebergs; for we know that icebergs have great influence as transporters of cold.

In particular cases the effect of a comparatively slight fall of summer temperature would be very great. I quote from Forbes's 'Norway and its Glaciers,' p. 215 :—

"Though the surface actually covered by perpetual snow in Norway be small, yet the mountainous districts and tablelands everywhere approach it so nearly that the snow-plane may be said to *hover* over the peninsula, and any cause which should lower it even a little would plunge a great part of the country under a mantle of frost."

And again, p. 243 :—

"It is exceedingly probable that a diminution of the temperature of the summer months by 4° only would at once place *one-fourth* of the surface of Norway within the snow-line; and so vast a mass of snow would refrigerate the climate, especially the summer temperature, to such a degree as would unquestionably pour glaciers into the head of every fiord in western Norway. . . . The lowering of the snow-line over so large a surface would deteriorate the climate and lower the mean temperature, which would lower the snow-line still further."

The change in the eccentricity of the earth's orbit is in all probability amply sufficient to account for this or a much greater change in summer temperature.

I take the following data from Mr. Croll's paper. The recently ascertained error in the old determinations of the sun's distance affects both distances alike, and consequently does not affect their ratio. Along with the maximum distances of the sun at present and at greatest excentricity, I state the proportionate quantities of heat the earth will receive under those two different conditions :—

	Sun's maximum distance.	Ratio of heat received.
At present	96,473,205 miles	100
At greatest excentricity . .	102,256,873 „	90

So that in the one case the earth receives about one-tenth less heat than in the other.

The sun's maximum distance occurs at present a little after the midsummer of the northern hemisphere. When it occurred at the same time of the year during the period of greatest excentricity, the earth at our midsummer was receiving only nine-tenths of the quantity of heat which it now receives at that time of the year. I cannot calculate the effect on climate; but it must have been very great, not only directly, by depressing the snow-line, but, as Forbes remarks in the place cited above, indirectly by chilling the air—and, I will add, by filling the North Sea with the icebergs which must have broken off from the glaciers that filled the Norwegian fiords, as they do now from the glaciers of Greenland. We have plenty of evidence of iceberg action during the glacial period.

I believe I have shown that glaciation depends chiefly on a cold summer, but partly also on an abundant snow-fall. I have now to show that a period of cold summers, caused as I have explained, must be also one of snowy winters; so that the two conditions favourable to glaciation will occur together.

During the mild winter of the glaciated hemisphere, there is a hot summer in the opposite one. Increase of temperature promotes increase of evaporation in a much greater ratio than that of the increase of temperature; and increased evaporation in the summer hemisphere will produce increased snow-fall in the winter one. We know that at present the vapour raised in one hemisphere is to a great extent precipitated in the other; for, were it not so, the southern hemisphere, by reason of its greater extent of ocean surface, would have a rainier climate than the northern; and such does not appear to be the case on the whole. Besides, during a glacial period, the atmospheric circulation between the two hemispheres, at the time of the earth's minimum distance from the sun (which on my theory was in the winter of the glaciated hemisphere), must be more active than ever it is now; for when the earth, at either solstice, was nearer the sun than is ever the case now, and the difference of temperature between the two hemispheres consequently at its greatest possible amount, this would produce a very active circulation of atmospheric currents between the two hemispheres, which would involve the deposition as rain or snow in the winter hemisphere of a great part of the moisture evaporated in the summer one.

Some interesting collateral observations remain to be made.

I believe that the foregoing remarks furnish the explanation of a very remarkable fact in physical geography. Not many coasts in the world are cut up into fiords; and all, or nearly all, that are so, are western coasts in high latitudes. The fiord formation is found in North-western Europe, including Norway, the west of Scotland, and the west of Ireland, in North America from Vancouver's Island northwards, and in South America from the island of Chiloe southwards. From Vancouver's Island to Chiloe is an immense stretch of nearly straight coast-line; but at those limits its character changes quite abruptly. The transition from straight to indented coast-lines coincides pretty nearly with that from dry to moist climates; and the change from the dry climate of Chilé to the moist one of western Patagonia is accompanied, as we might expect, by a great depression in the snow-line on the Andes. (See tabular statement above.) It is now generally believed that the prevalence of lakes in high latitudes is, in some way, a result of glacial action; it can scarcely be doubted that this is equally true of fiords; and the coasts I have mentioned are those on which glacial action must necessarily be the most energetic, because west coasts, in high latitudes, are exposed to west winds (Maury's "countertrades"), which deposit on the mountains in snow the moisture they have taken up from the sea.

Geologists appear to be now agreed that the carboniferous climate was not one of great heat, but moderate and moist. If so, the glacial and the carboniferous climates may have coexisted, being only separated by a few degrees of latitude. We see an approach to such a state of things at present; in the straits of Magellan the climate is so far glacial that glaciers reach the sea and give origin to icebergs, while in the Falklands it is so far carboniferous that all the vegetation, and that not mosses but flowering plants, is converted when dead into peat.

If I am right that both hemispheres were never glaciated at once, it follows that the equatorial regions were never glaciated at all; and this accounts for what Darwin remarks with surprise, that the vegetable species of the tropics have undergone much less extinction during the glacial period than might have been expected ('Origin of Species,' 4th edition, p. 454). But he regards it as proved that at a comparatively recent period, which in all probability was the glacial, there has been a good deal of intermigration of species between the two temperate zones, which must have crossed the equator when its temperature was cooler than it is now. Both of these facts may be explained by supposing, what is in itself very probable, that during the glacial period the equatorial climate was much what it is now, except in some places which were cooled by ice-bearing currents. The floating ice would also be a most efficient agent in transporting seeds. Agassiz and Mr. Wallace have found traces of glacial action in the valley of the Amazon—action of icebergs probably, not glaciers; for no one supposes that the valley of the Amazon, from the Andes to the Atlantic, was ever filled with a glacier (Alfred R. Wallace on Ice-marks in North Wales, 'Quarterly Journal of Science,' Jan. 1867).

M. Martins (in his article on "Les Glaciers actuels et la Période Glaciaire," Revue des deux Mondes, March 1, 1867) objects to Mr. Croll's theory, that it would require the glacial periods of the two hemispheres to have occurred at different times, while geological evidence shows that they occurred at the same time. If this objection is valid against Mr. Croll's theory, it is equally valid against mine; for mine is, in fact, only Mr. Croll's inverted: his theory and mine place the glacial epochs of the opposite hemispheres in opposite periods of the same cycle.

I reply to this that geological evidence does not and cannot show whether a glacial period in the northern hemisphere and in the southern—in Scotland, for instance, and in Patagonia—were actually contemporary or separated by an interval of several thousand years. The period during which the excentricity of the earth's orbit is near its maximum is very long, several times 25,000 years. The precession of the equinoxes completes its cycle in 25,000 years, at the end of which time will recur the same position of the solstices with respect to the earth's perihelion and aphelion. According to my theory a glacial period occurs during the period of the greatest excentricity of the earth's orbit, at the time when the earth's aphelion is near the summer solstice; consequently it would occur in the same hemisphere after an interval of 25,000 years, and in the opposite hemisphere after half that interval, or 12,500 years. Now no geological evidence could detect an interval of 12,500 years between the dates of glacial scratches or of beds of drift in widely separated regions, such as Scotland and Patagonia. But according to M. Martins there is geological evidence of at least two glacial periods, with a geologically short interval between them; and such recurrent glacial periods ought to be expected on either Mr. Croll's theory or mine.

It is to be observed, in conclusion, that Mr. Croll's reasoning and mine leave untouched the arguments by which Sir Charles Lyell has endeavoured to show how all changes of climate may be referred to geographical causes, especially to changes in the distribution of land and water, and changes in the direction of the ocean-currents produced by these. The climate of any region at any period is due to a complication of causes, some of which are geographical, and some astronomical. Sir Charles Lyell has dealt with the geographical ones, Mr. Croll and I with the astronomical ones. There is no doubt that the geographical causes of changes of climate are *veræ causæ*; but it is not so certain that they are fully adequate to account for the facts. It is equally certain that the astronomical causes also are *veræ causæ*; and I have endeavoured to show what their mode of operation must be.

Discussion.

Prof. Ramsay remarked that Prof. Dana and himself had both referred the origin of many fjords to the same cause as the author.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

NOTICE *of* PLANT-REMAINS *from* BEDS INTERSTRATIFIED *with the* BASALT *in the* COUNTY *of* ANTRIM. By WILLIAM HELLIER BAILY, Esq., F.L.S., F.G.S.

(Read January 27, 1869*).

[PLATES XIV. & XV.]

THE existence of deposits containing vegetable remains, interstratified with the basaltic rocks of the Island of Mull, was first made known by the Duke of Argyll, through the medium of this Society, in January 1851†.

This important discovery, from its supplying reliable, indications as to the climatal condition and period of eruption of the basaltic rocks of that portion of Scotland, also led to the inference that a corresponding age might reasonably be assigned to the basalt of the north of Ireland, a conjecture which could only be satisfactorily determined by actual proof of the association of similar plant-beds with the basaltic rocks of that part of the country.

This question is now rendered capable of solution by the required evidence having been obtained, during the progress of the Geological Survey of Ireland, in the neighbourhood of Antrim, where the late Mr. G. V. Du Noyer, District Surveyor, discovered a bed containing fossil plants, a large proportion of which are dicotyledonous leaves, interstratified with and lying between masses of basalt, and therefore occurring under very similar conditions to the leaf-beds of the Isle of Mull.

This plant-bed was exposed in a cutting through the basalt on the Belfast and Northern Counties Railway, between Templepatrick and Doagh Stations, about seven miles east of Antrim. From a rough section furnished me by Mr. Du Noyer in September 1868, the following measurements and descriptions are taken, the beds being enumerated in descending order.

* For the Discussion on this paper, see p. 162 of the present volume.

† "On Tertiary Leaf-beds in the Isle of Mull. With a Note on the Vegetable remains from Ardtun Head, by Prof. E. Forbes" (Quart. Journ. Geol. Soc. vol. vii. 1851, p. 89).

(1) Basalt, 15 feet; (2) brown earth, 3 inches; (3) layer of impure earthy lignite, 8 to 12 inches; (4) brown and red bole or earth becoming red at the lower portion and passing into the plant-layer, no. 5; (5) plant-layer, 4 to 8 inches thick; (6) conglomerate bed, principally composed of ironstone nodules, probable thickness 10 or 12 feet; (7) rails resting on basalt.

The condition in which these plant-remains are found is not quite so favourable for determination as that of those from the Isle of Mull: the fossils under consideration occur in a red clay, some parts of which are more or less arenaceous; the impressions, although preserving the outline of the leaf, do not in many cases show clearly the important character of venation*.

In addition to the specimens obtained by Mr. Du Noyer, a large number were collected by Mr. M'Henry, also of the Geological Survey, many of them from another part of the same railway-cutting; and although the series contains some well-defined examples of the vegetation of the period, it does not include a very great variety of forms.

The only specimen in which the generic character can be decided upon with any degree of certainty is that of a Fir-cone, named by me *Pinus Plutonis*, Pl. XV. fig. 1, *a* & *b*; this cone may be compared with that of the *Pinus pinaster* or Cluster Pine, especially to the variety *maritimus*, the fruit of which is composed of large and hard scales†; in the collection are also many fragments of the branches of another coniferous tree, the stem of which was covered with small elongated tapering leaves, Pl. XV. fig. 4, *a* & *b*. I have named this *Sequoia Du Noyeri*, in memory of the lamented gentleman to whom we owe the discovery of this plant-bed. It resembles very closely *Sequoia Sternbergi*, Heer‡, from Iceland, but differs in the relative size and closer arrangement of the leaves on the stem. The only recent example with which I had an opportunity of comparing it was *Sequoia sempervirens*, the Red Cedar of California; the more open arrangement of the leaves on the branches of that tree offers, however, a closer comparison with the fossil plant from the Isle of Mull, doubtfully referred by Professor Forbes to *Taxites* §; I think

* In reply to a remark made during the discussion on this paper, at the reading of which the author was unavoidably absent, he begs to state that whilst fully impressed with the desirability of using great caution in the determination of species from insufficient data, he feels quite justified in applying names to such specimens as the *Sequoia*, *Pinus*, and *Cupressites*, with respect to the generic affinities of which there can be but little doubt; the remaining specimens, principally leaves, he did not attempt to identify positively, but, after careful comparison with the works of Unger, Massalongo, Heer, &c., merely ventured to suggest the possibility of their belonging to certain genera and species figured by those authors from probably contemporaneous deposits. In reference to this subject the author would beg to refer to Prof. Forbes's remarks on the fossil plants he named from the Isle of Mull, anticipating an objection of this kind, in his note to the Duke of Argyll's paper before cited.

† These cones, which must have been at least 3 inches long, are called by the workmen employed in excavating the iron-ore "Firs;" they occur in a black carbonized condition, and are said by them to be not unfrequent.

‡ Flora Fossilis Arctica, p. 140, pl. 24. fig. 9.

§ Quart. Journ. Geol. Soc. vol. vii. pl. 2. fig. 1.

it therefore very possible that fossil may have belonged to the same genus*.

A small cone is perhaps the fruit of the fossil I have figured as *Sequoia Du Noyeri*. Fragments of other fossils such as that drawn on Pl. XV. fig. 5, *a* & *b*, I have referred to *Cupressites*, naming the species *C. MacHenrii*: the imbricated character due to the peculiar arrangement of the leaves on the terminal branches is very evident in some specimens, resembling very closely that of the ordinary Cypress, *Cupressus sempervirens*.

A large proportion of these fossils consists of leaves of Dicotyledonous plants, the principal varieties being shown on Pl. XIV. Most abundant amongst them are ovate and acuminate leaves, with entire or non-serrate margins, and a simple character of venation (Pl. XIV. figs. 7, 8); they resemble so nearly some of the species of *Rhamnus* figured by Prof. A. Massalongo in 'Flora Fossile Senigalliese, and by Dr. Oswald Heer in 'Flora Fossilis Arctica,' as to induce the belief in the probability of their generic identity, and of their having belonged to trees or shrubs of the Rhamnaceæ or Buckthorn Order. Some linear-lanceolate leaves, having entire margins and a strong midrib, on which, however, no other trace of venation is perceptible (Pl. XIV. figs. 3, 4), are so much like those figured by Massalongo under the names of *Olea* and *Andromeda*, as to have probably belonged to the Order Oleaceæ.

A large ovate leaf (Pl. XIV. fig. 2) having an obsoletely serrated margin is comparable with species of *Fagus* figured by both Massalongo and Heer, approaching very closely to *Fagus incerta*, Massal.† Other leaves (Pl. XIV. figs. 5, 6), tapering at each extremity and having closely arranged ribs and a non-serrated margin, resemble some forms of *Quercus*, such as *Q. nereifolia*, in 'Flora Foss. Senigalliese, pl. 31. f. 6, and the evergreen oak, *Q. ilex*.

Parallel-ribbed stems or leaves of Endogenous plants, such as may have belonged to Sedges or Grasses, are not unfrequent in the collection.

A large mass of fossil wood partially oxidized was procured from the bed with iron-ore; it exhibits the structure very clearly, and is evidently dicotyledonous‡.

Several fruit- or seed-vessels of different kinds, some of which are shown on Pl. XIV. figs. 9–13, occur in the same bed, as well as a few remains of insects, two very small elytra or wing-cases of beetles of

* Since the above paper was read, I find on looking into Sir Charles Lyell's 'Elements of Geology,' sixth edition (1865), that in his account of the Isle-of-Mull leaf-beds he mentions, on the authority of Professor Heer, *Sequoia Langsdorfii* as being the most prevalent conifer in those beds. The figures he gives of that species on pp. 261 & 262 are so much like the fossil alluded to above, and named by Forbes *Taxites? Campbelli*, that it is doubtless the species he identifies with *S. Langsdorfii*, and this is confirmatory of the remarks I had offered in the above paper, before seeing this paragraph, as to the probability of its belonging to the genus *Sequoia*.

† 'Flora Fossile Senigalliese,' pl. 33. fig. 6.

‡ Since writing the above I have been enabled to examine this fossil wood with the microscope and to make out distinctly its coniferous structure, as shown in the enlarged representations, Pl. XV. fig. 3, *a* & *b*.

distinct species resembling those of some of the smaller Carabidæ, one of them (fig. 14) having an arrangement of puncta like that on some of the weevils or small diamond-beetles. The only two specimens observed are very minute, and are figured on Pl. XIV. figs. 14, 15.

So far as can be judged from a preliminary examination such as this, these plant-remains from between the Basalts of Antrim appear to differ as a group from those obtained in corresponding beds at the Isle of Mull.

The majority of the plants from the Ardtun Head, as stated by Professor Forbes, consisted of palmate leaves having three or more lobes, referred by him to *Platanites**, from their resemblance to the Plane or Sycamore. Throughout the collection from the north of Ireland there is at present no evidence of any leaves of this form, the majority being simply ovate or lanceolate with entire margins; there is, however, considerable resemblance between some of these and the leaves he figures under the name of *Rhamnites*†.

A generic identity may also be found to exist between the plant I have referred to *Sequoia* and that doubtfully assigned by Forbes to *Taxites*‡; in the former, however, the leaves are more numerous, surrounding the stem more closely; and it approaches so nearly *Sequoia Sternbergi*, Heer, that I have but little hesitation in including it in the same genus.

No indication of Ferns or Equisetum-like plants, such as were described from the leaf-beds of the Isle of Mull, has yet been observed amongst these Antrim fossils. The presence of large fragments of wood is also a distinctive feature amongst these plants from the north of Ireland, the Duke of Argyll in his description having specially remarked on the absence of any fragments of trees larger than the merest twig in the plant-deposits of the Isle of Mull.

Although the specimens are not generally in a sufficiently perfect state of preservation for specific identification, there is perhaps enough to indicate their alliance with mid-European forms; and though not specifically identical with those from the Isle of Mull, like them, they most probably belong to a corresponding epoch in geological time, that of the Miocene.

Description of the Species named.

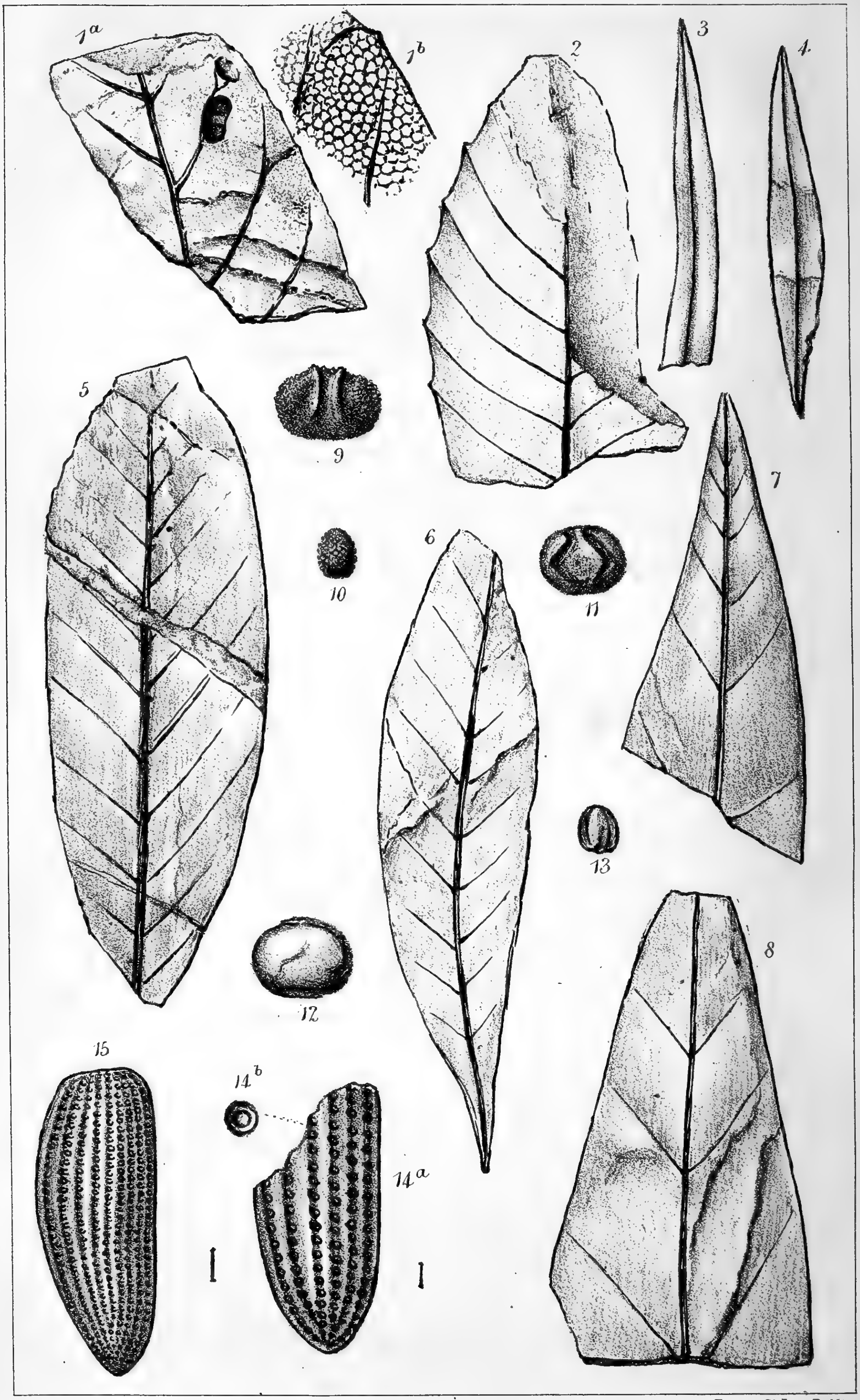
Pinus Plutonis, Baily. Plate XV. fig. 1, *a* & *b*, and fig. 2.

Fruit or cone of a Fir, ovate and elongate, composed of large broad scales, each marked with a semicircular and central ridge; base of scales striated. Length of cone about 3 inches; diameter at widest part $1\frac{1}{4}$ inch. The separate scale (fig. 1 *b*) and the section on the same Plate (fig. 2) most probably belong to one species.

* *Platanites hebridicus*, Forbes, Quart. Journ. Geol. Soc. vol. vii. pl. iii. f. 5, and pl. iv. f. 1. Sir C. Lyell suggests the identity of this species with *P. aceroides*, 'Elements of Geology' (1865), p. 240.

† Quart. Journ. Geol. Soc., vol. vii. pl. iii. figs. 2, 3, 4.

‡ See *ante*, p. 359, and footnote.



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ANTRIM FOSSIL PLANTS, &c.

Locality. Not unfrequent in the red-bole or ochre bed, which passes into an iron-ore deposit, interstratified with the basalt, railway-cutting between Templepatrick and Doagh stations, Belfast and Northern Counties Railway.

Sequoia Du Noyeri, Baily Plate XV. fig. 4, *a* & *b*.

Branches covered by closely arranged, elongate and acuminate leaves, each with a strong, longitudinal, median depression.

This species is closely allied to *S. Sternbergi*, Goepp., sp., figured by Prof. Heer in 'Flora Fossilis Arctica' (p. 140, pl. 24. figs. 7–10), but differs in the closer and more imbricated character of the arrangement of the leaves upon the stem.

It occurs at the same locality and in the same deposit as the preceding species.

Cupressites MacHenrii, Baily. Plate XV. fig. 5, *a* & *b*.

Leaves small and closely imbricating, branches alternating and divergent.

Allied to *C. pychnophylloides*, Massalongo, 'Flora Fossile Senigalliese, p. 151, pl. 5. figs. 17, 18, 19.

In iron-ore deposit, from the same locality as the previous species.

EXPLANATION OF PLATES.

Illustrative of Fossil Plants from Beds interstratified with the Basalt of Antrim.

Plate XIV.

Fig. 1. ?*Platanus*: *a*, portion of leaf showing reticulated surface; *b*, part of the same enlarged. This specimen has the cast of a seed impressed upon it.

2. ?*Fagus*. An imperfect ovate leaf, with an obsoletely denticulate margin; allied to *Fagus incerta*, Massalongo, Flora Senigalliese, pl. 30. fig. 3.

3. Upper portion of a narrow lanceolate leaf, probably allied to *Podocarpus medoacensis*, Mass. ibid. pl. 34. fig. 20.

4. ?*Andromeda*. A small linear-lanceolate leaf, probably allied to *Andromeda vetuloniæ*, Mass. ibid. pl. 34. fig. 13.

5. ?*Quercus*. Lanceolate leaf, resembling that of the Evergreen Oak (*Quercus Ilex*).

6. ?*Quercus*. Lanceolate leaf, tapering at each extremity, allied to *Quercus nereifolia*, A. Braun in Mass. ibid. pl. 31. fig. 6.

7. ?*Rhamnus*. Upper portion of an acuminate leaf resembling *Rhamnus Deckenii*, Web. in Mass. ibid. plates 26 & 27, and 30. fig. 7.

8. ?*Rhamnus*. Portion of an acuminate leaf, most probably identical with the preceding (fig. 7).

9, 10, 11, 12, 13. Carpolithes, undetermined.

14. *a*. Elytron of a small beetle with peculiar punctation (enlarged); *b*, a single punctum more highly magnified.

15. Elytron of a small beetle, rather larger in size than the preceding one (fig. 14) and with more closely set and more numerous puncta (enlarged).

These minute wing-cases, the natural size of which is shown by the adjacent lines, in shape and mode of punctation are not unlike those of the

Weevil-tribe, Rhynchophora (especially the genus *Apion*), which are phytophagous. The one represented by fig. 14 in the peculiar character of its puncta especially reminds us of the markings on some insects of the subfamily Entimides, to which the Diamond-Beetle belongs.

Plate XV.

Fig. 1. *Pinus Plutonis*, n. sp.: *a*, cone of a Pine with large scales, allied to *Pinus Saturni*, Mass., *op. cit.* pl. 5. fig. 34; *b*, a detached scale; *c*, a leaf, most probably of the same species.

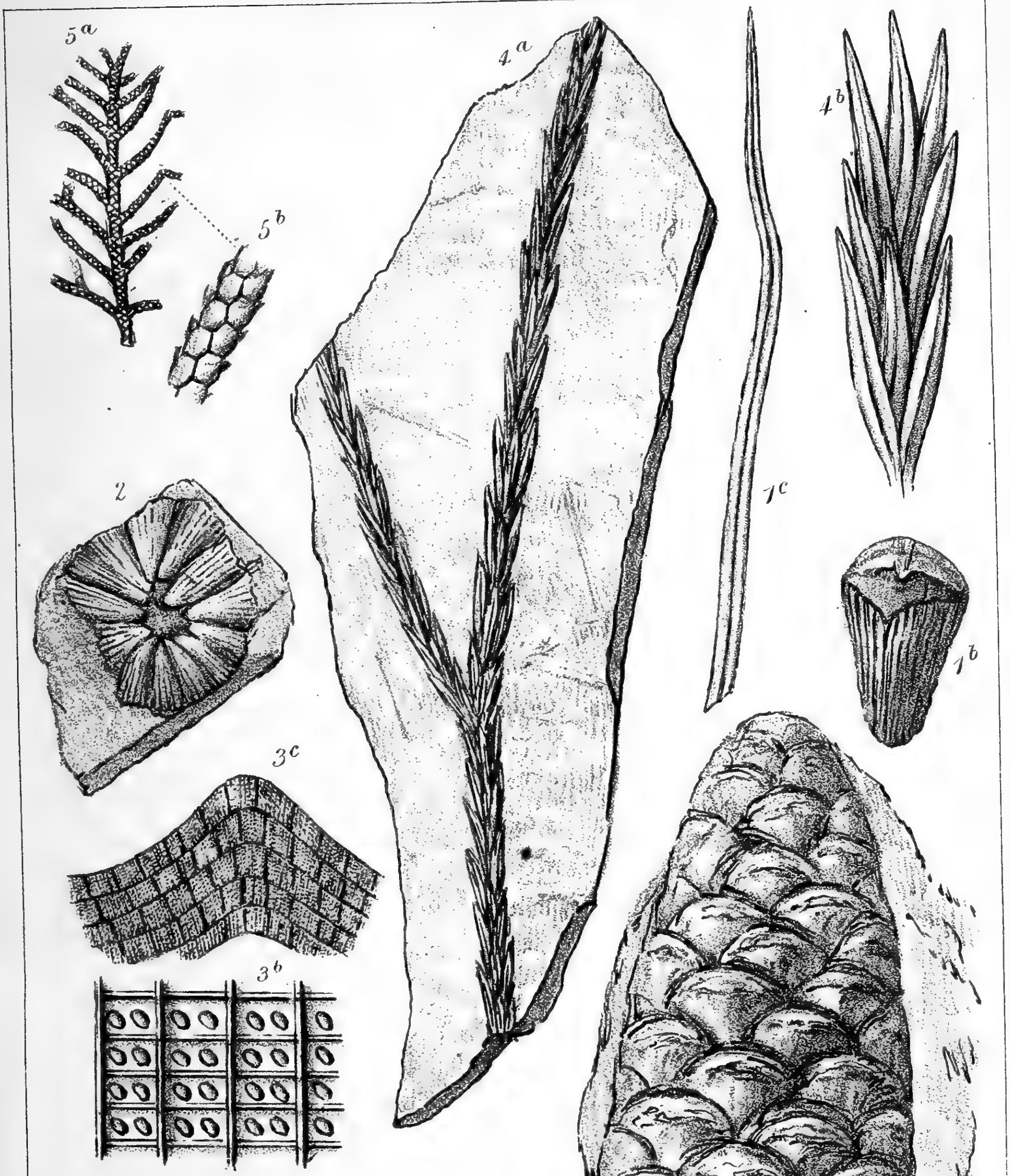
2. *Pinus.* Section of a cone, probably identical with the preceding species (fig. 1).

3. Coniferous wood, highly magnified: *a*, longitudinal section, ligneous tissue, showing the punctated character of a conifer; *b*, portion of the same, still more highly magnified; *c*, transverse section of the same wood, showing medullary rays and intermediate cellular tissue.

4. *Sequoia Du Noyeri*, n. s.: *a*, diverging branch with close-set linear-lanceolate leaves; *b*, enlarged portion. Allied to *Sequoia Sternbergi*, Goepp., sp., in Heer's 'Flora Fossilis Arctica,' pl. 24. figs. 7–10.

5. *Cupressites MacHenrii*, n. s.: *a*, portion of a small branch with imbricated leaves; *b*, enlarged portion. Allied to *Cupressites pychnophylloides*, Mass. ibid. pl. 5. figs. 17, 18, 19.

All the figures are of the natural size, except where otherwise stated.



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ANTRIM FOSSIL PLANTS.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

June 23, 1869.

G. H. Wollaston, Esq., of the Geological Survey of England and Wales; Richard Pearce, Esq., Swansea; Richard Moreland, jun., Esq., Old Street, London; James N. Shoolbred, Esq., B.A., Assoc. Inst. C.E., 3 York Buildings, Dale Street, Liverpool; Fritz Gillman, Esq., 14 Ashley Place, Westminster, S.W.; and Richard Abbay, Esq., B.A., Fellow of Wadham College, Oxford, were elected Fellows of the Society.

The following communications were read:—

1. *On two New Species of* Gyrodus. By Sir Philip de M. Grey-Egerton, Bart., M.P., F.R.S., V.P.G.S.

1. Gyrodus Goweri, Egerton.

Monsieur Thiollière in his splendid work on the fossil fishes of the Jura formation of Bugey—a work of singular merit cut short by his untimely death—when speaking of the Pycnodonti of Agassiz, says truly that "this family has the advantage over many others of the Ganoid Order in the circumstance that the characteristic features are true and easily appreciable, such as the form and arrangement of the oral apparatus, the peculiarity of the scales, and the structure of the vertebral column." In fact, this family is in a manner isolated from all others, and consequently (if the Acanthodei be excepted) has been subjected to fewer modifications than any other of the Ganoid Order during the long period which has elapsed since its establishment by Professor Agassiz. Some of the most distinguished palæontologists have directed their attention to this subject: Quenstedt, Wagner, Heckel, Thiollière, Pictet, Costa, Knerr, Sauvage *, and Lütken have all written on the Pycnodonti, and have contributed much information in developing the characteristics of the family, and rectifying some of the generic characters assigned by Agassiz. Many more species have also been added, exemplified by specimens of rare perfection, as may be seen by consulting the beautiful plates given in the works of Thiollière and Heckel. Perhaps the latter author has contributed more than any other observer to the typical characters of the several genera; but as his work is limited to specimens found in the Austrian dominions, other writers must be consulted for species found in other parts of the Continent. The genus *Gyrodus* is distinguished from the other Pycnodonti by the form of the tritoral teeth, the deeply forked tail, the solidity of the scales, some peculiarities in the vertebral apophyses, and by the presence of scale-ribs both before and behind the dorsal fin. The peculiar mechanism of these scale-ribs was first interpreted by myself in a paper communicated to the Geological Society in 1849 †. Thiollière has fully comprehended and clearly described this scale-structure peculiar to the *Pycnodonti* ‡; but Dr. Lütken speaks of "the peculiar manner in which the scales are interlocked and attached to those ribs" §, as if they were independent organs, whereas the rib or fillet is composed of the thickened margins of the scales, homogeneous in structure, and inseparable from them except by fracture, and each of these so-called dermal ribs is made up of as many pieces as there are scales in the dorso-ventral series. Heckel is of opinion that these dermal ribs are analogous to the so-called V-shaped ossicles present in the ventral region of some recent fishes of the Clupeoid family, only more largely developed, and he names them *ridge-ribs* and *keel-ribs* (Firstrippen und Kielrippen ||)—a solution originated by Prof. Agassiz ¶, but since abandoned in favour of the explanation which I have suggested. Having made a careful examination of a much larger number of specimens, and in more perfect condition than were available in 1849, I find no reason to alter or modify the observations I then published; on the contrary, I find them confirmed by indisputable evidence. Heckel and Thiollière are both in error in describing the dental formula of the lower jaws of the Pycnodonti as limited to four rows of tritoral teeth on each side. I have several mandibles from the Oolite of Stonesfield and the Jura beds of Soleure, in which a fifth row of small teeth occurs on the inner margin of the jaw; and Thiollière has himself represented this row in a specimen of *Pycnodus Bernardi* (*Microdon* of Heckel) figured in plate v. fig. 2 of his work on the fossil fishes of Bugey.

* 'Catalogue des Poissons des Formations Secondaires du Boulonnais,' par Emile Sauvage, 1867. M. Sauvage having used the term *Eulepidotæ* in his publication, it becomes incumbent on me to change the somewhat similar name *Eulepidotus* given to a section of the *Lepidoti* in a paper read on the 17th of June 1868: I propose to substitute for it the name *Heterolepidotus*.

† Quart. Journ. Geol. Soc. 1849, p. 330.

‡ 'Poissons Fossiles du Bugey,' p. 12. § 'Geological Magazine,' vol. v. p. 431.

|| 'Beiträge zur Kenntniss der fossile Fische Oesterreichs,' p. 10.

¶ 'Poissons Fossiles,' vol. ii. pt. 2. p. 182.

The specimen under consideration was found by the Rev. Mr. Joass, of Golspie (to whom we are indebted for the discovery of the rich deposit of Devonian Ichthyolites at Edderton in Rosshire), on the beach between Culgower and Portgower, on the east coast of Sutherlandshire. It is imbedded in a dark-coloured shale perforated by recent Pholades, and incrusted in places by Balani. The head and tail are deficient; but the trunk is tolerably well preserved, with the exception of the fins. It measures eleven inches in length by seven or more in depth: as the ventral scales are absent, the latter measurement is merely an approximation. Fortunately two of the tritoral teeth are preserved. Although not *in situ*, there can be no reason to doubt that they belonged to the specimen. They present all the typical characters of the teeth of the genus *Gyrodus*, viz. a small central papilla surrounded by two crenulated rings, the inner one rather higher than the outer one, having the appearance, viewed vertically, of a small rosette (fig. 1). Judging from their circular form and relative size, it is probable that they belonged to one of the secondary rows of the vomerine series. The column, as is the case in all the members of this family, is notochordal. The neurapophyses, especially in the nuchal region, are strong, and extend nearly to the dorsal ridge. They are spathulate at the lower extremities, where they partly embrace the chorda. The impressions of a few of the interspinous ossicles supporting the rays of the dorsal fin show that this organ occupied nearly the centre of the back. No evidence remains as to the position or characters of the other fins. The whole of the trunk is invested with a compact scaly armour, remarkable for the solidity of the component scales, and the strength of the joints by which they are united. In most of the Ganoid fishes the scales are united by a pin-and-socket lock, each scale having a process at the upper anterior angle, which is received in a depression on the lower angle of the scale immediately above it in the series; but in this case each scale has a superior and inferior process, which are spliced to the corresponding processes in the contiguous scales above and below; in addition to which, additional strength is imparted by a broad overlap at each joint, the upper scale covering the bevelled margin of the succeeding scale below (fig. 2). When viewed on the inner surface, these processes form the continuous rib or fillet which has been alluded to before. *Gyrodus* is the only genus of the secondary formations in which this structure prevails behind the dorsal and anal fins; this peculiarity has therefore been taken as a good feature for rectifying the generic nomenclature of the several species. The genus *Microdon* of Agassiz (as I pointed out in 1849) comprised some species in which the peculiar scale-structure was partial, and others in which it was general; the latter species, namely *Microdon hexagonus* and *M. analis*, are now correctly arranged by Heckel under the genus *Gyrodus*; on the other hand, *Gyrodus micropterus* of Agassiz differs from that genus in having no scale-ribs on the posterior half of the body, as also in having very large dorsal and anal fins and a rounded tail. These characters combined justify Wagner in making it the type of a new genus, *Mesodon*, to which must be added *Gyrodus gibbosus*, Münster, and *Pycnodus liassicus*, described by myself in the 8th Decade of the 'Memoirs of the Geological Survey,' plate x. On comparing the Scotch specimen with the other species of *Gyrodus* of which the characters of the scales are known, I find it differs from them all; I have therefore ventured to give it a specific name, although it is impossible to affirm it to be a new species until more is known of the many species of the genus which have been named from the teeth alone. The scales in this specimen are very large, and have a dense lustrous surface of ganoine. Some of these, on the flanks, measure above an inch in length, including the processes. The lateral line traverses the several series of scales below the column; the scales above this line decrease in size to the dorsal ridge-scales, while below it they increase nearly to the ventral border. The scales in the hinder part of the body are considerably smaller than those in front; but they retain the characteristic surface-ornament throughout. This consists of an elaborate pattern in relief, composed of vermicular fillets interspersed with granules, which covers the whole exposed portion of the scales. At the two extremities of the trunk the granules preponderate over the labyrinthic pattern. The nearest approach to this scale-armature is found in a gigantic specimen from Solenhofen, in the Munich Museum, called *Gyrodus rhomboidalis*; but there are strongly marked differences between this and the Scotch species.

Fig. 1.—*Tooth of* Gyrodus Goweri.

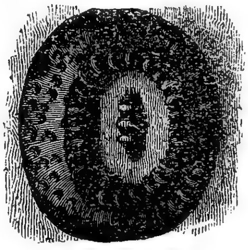
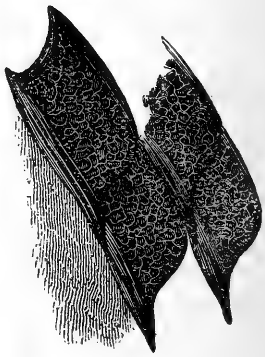


Fig. 2.—*Scale of* Gyrodus Goweri.



Mr. Joass is unable to point out the particular bed from which this specimen is derived, but he says it was apparently beneath the siliceous sandstone of Braambury Hill, and decidedly above the calcareous grits, clays, and shales of Dunrobin. On referring to Sir Roderick Murchison's paper on the "Coalfield of Brora"*, I find the beds exposed on the coast between Culgower and Portgower are considered to belong to the middle portion of the Oolitic series,

* Trans. Geol. Soc. 2nd series, vol. ii. pl. xxxi.

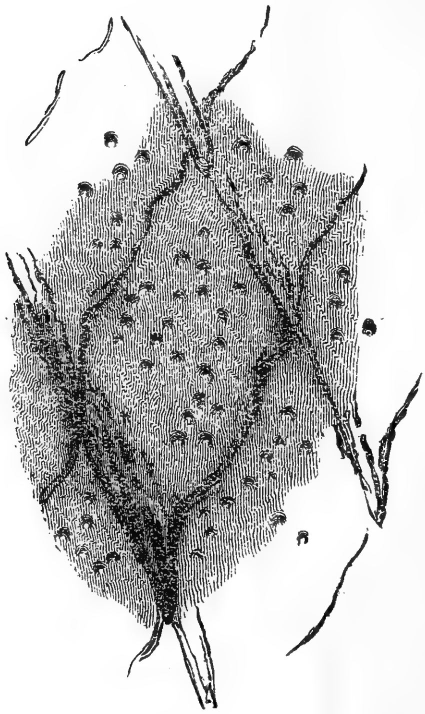
viz. the Oxford clay, Cornbrash, &c. This is just the period in which the genus *Gyrodus* seems to have attained its maximum development. No species has yet been discovered in the Trias or Lias. A few occur in the Lower Oolites, from which period the genus expands enormously through the remainder of the Oolitic series, decreasing again in the Wealden, and finally disappearing in the Cretacean era. I have named this species *Gyrodus Goweri* in recognition of the great interest the Duke of Sutherland takes in all questions affecting the county of Sutherland, which has been remarkably shown by his establishing a museum at Dunrobin Castle for the reception of specimens of science and antiquity connected with the county, for the amusement and instruction of those who visit the charming scenery of the neighbourhood of Golspie.

2. Gyrodus coccoderma, Egerton.

The Museum of Practical Geology possesses a portion of a large Pycnodont fish referable to the genus *Gyrodus*, from the Kimmeridge Clay of Kimmeridge. The specimen is a mere fragment, containing only a group of scales from the nuchal and dorsal region, above the lateral line, and before the dorsal fin. It measures 1 foot in length by 7 inches in depth. Judging from the proportions of other species of the genus *Gyrodus*, this fish, when perfect, must have been at least 30 inches in length, from the snout to the commencement of the tail, by 20 inches in depth, rivalling in size the great *Gyrodus rhomboidalis* of the Munich Museum.

It contains twelve dorso-lateral series of scales, with eight scales in each row, measuring each 1 inch in antero-posterior diameter. They vary in depth and form according to the position they occupy in the series. Those nearer the top of the back are the shortest, and are lozenge-shaped; the succeeding scales in each row become more elongated in descending order, so far as they are preserved. The scales of the flanks are unfortunately not present; they would probably have been from $2\frac{1}{2}$ to 3 inches in length. The surface-ornament of the scales (fig. 3) is well seen, and is very peculiar. It consists of a multitude of symmetrical granules of hard and lustrous ganoine, like grains of millet-seed, irregularly scattered over the surface. On the nape and back they are thickly grouped, but more sparsely sprinkled over the other parts. Each granule maintains its form, even where they are most crowded, and has no tendency to coalesce with its neighbours to constitute the meandrine pattern so frequently found on scales with raised patterns. It differs in this respect from *Gyrodus Goweri* and *Gyrodus rhomboidalis*, but somewhat resembles a little-known species from the Oolite of Stonesfield, named by Agassiz *Gyrodus perlatus*—the articulating processes of the scales forming the dermal ribs, and being very strong, and coarsely striated longitudinally. They measure half an inch in length. I have given the specific title *coccoderma* to this fish, from the characteristic features of the scales.

Fig. 3.—*Scales of* Gyrodus coccoderma.



Mr. Etheridge having kindly directed my attention to some specimens of Pycnodont teeth deposited in Jermyn Street by Mr. Mansel, I found amongst them a fine example of the vomer of a *Gyrodus* (fig. 4), which, from its size, may very possibly have belonged to *Gyrodus coccoderma*. This conjecture is strengthened by the fact that it was found in the same stratum and in the same locality, viz. in the Kimmeridge Clay of Kimmeridge. The dentigerous area of the bone measures two inches and eight-tenths in length. The breadth at the base is one inch and three-tenths, and at the apex seven-tenths of an inch. It is furnished with five rows of teeth. The median row contains nine large circular tritores, much abraded on the grinding surface. A tenth tooth is wanting at the base. Next in size come the marginal rows. One of these contains fourteen, the other (imperfect) thirteen teeth. They differ in form from those of the median row in having the outer periphery truncated, and the outer edges raised. Although somewhat used, they still retain the gyrations characteristic of the genus. The intermediate row contains the smallest teeth. There are fourteen in each row, rather irregular in form, but more or less circular. The surfaces are deeply furrowed, as they have suffered little from use. This specimen differs from all the vomerine remains of *Gyrodus* yet figured; it approaches more nearly to a species named *Pycnodus Dutertrei* by M. E. Sauvage, from the Portlandian rocks of Portel, which may possibly be a *Gyrodus* having the teeth much worn;

but from this it differs in having the median teeth circular, instead of transversely oval.

Another specimen belonging to Mr. Mansel is one of great interest. There has long been a controversy touching the validity of the genus *Sphærodus.* The similarity of the teeth to those of some of the larger species of *Lepidotus* induced Agassiz to establish the genus with some hesitation. Owen, however, detected some differences in the microscopic structure of the tooth, which led him to consider the two genera distinct. Many continental palæontologists, on the other hand, repudiated the genus *Sphærodus,* as founded in error. The main obstacle to a satisfactory solution of the difficulty arose from the circumstance that the Bufonites were generally found detached from the dentary bones. In Mr. Mansel's specimen (fig. 5), however, we have true *Sphærodus* teeth arranged

Fig. 4.—*Vomer of* Gyrodus coccoderma.

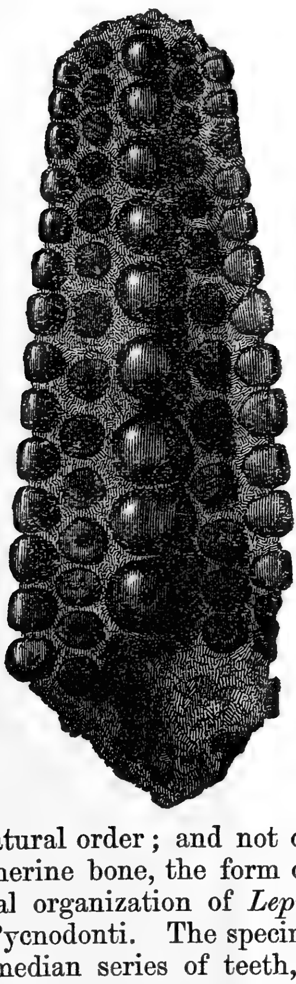
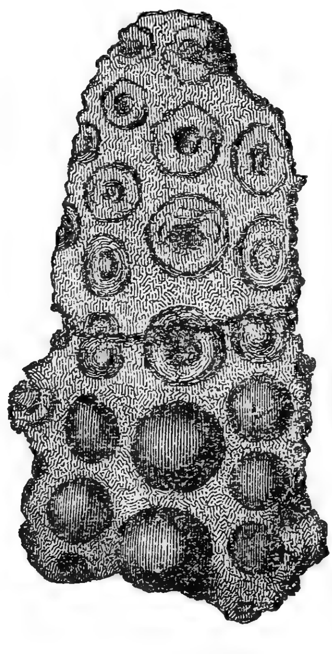


Fig. 5.—*Vomer of* Sphærodus gigas.



in natural order; and not only so, but the specimen is fortunately a vomerine bone, the form of which is entirely different from the palatal organization of *Lepidotus,* and essentially characteristic of the Pycnodonti. The specimen is 2½ inches in length, and contains the median series of teeth, the two intermediate rows, and two teeth of the marginal row of the left side. The median row is composed of six teeth of circular form; the intermediate rows contain seven, also circular, teeth in each; the teeth of the marginal row are slightly truncated on the outer edge. This specimen was also found in the Kimmeridge Clay at Kimmeridge, and must probably be referred to the species named by Agassiz *Sphærodus gigas*.

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2. *Note on a large* Saurian Humerus *from the* Kimmeridge Clay *of the* Dorset Coast. By J. W. Hulke, Esq., F.R.S., F.G.S.

[Plate XVI.]

For the opportunity of bringing before the Society this remarkable bone I am indebted to the great courtesy of J. C. Mansel, Esq., who, in reply to an inquiry addressed by me to him respecting the genus *Pliosaurus*, most liberally transmitted to me for study a large number of specimens from his unrivalled collection of Saurian bones from Kimmeridge, amongst which was the subject of this note. Mr. Mansel writes to me that this bone was found last year "amongst the layers of shale immediately above the band of cement-stone which rises from E. to W. on the west side of Clavell's Tower, between Kimmeridge Bay and Clavell's Head;" and he called my attention to it as differing from the common Enaliosaurian limb-bones.

Description.—This stupendous bone has transversely elongated extremities and a subcylindrical shaft. It has been broken across at about 7 inches from its proximal extremity, and again 1 foot from its distal end. Owing to the loss of small portions by splintering and abrasion, the surfaces of the distal fracture do not meet accurately. A long slip, reaching from this fracture to the anterior* angle of the proximal terminal surface and including a small piece of this latter, has been broken off the anterior (outer) border of the bone and is wanting, as are also both the terminal epiphyses†. The terminal surfaces are mammillated and rugous, and scarcely at all abraded. The surface of the shaft is smooth and polished, composed of a very dense cortex which in this situation is about ·5 inch thick, but which grows thinner towards the extremities, where also its texture is less compact and its surface is rougher and coarsely striated. There is no medullary canal. All the fractured surfaces distinctly show the interior to consist of cancellous tissue.

Proximal extremity.—This is much flatter than the distal. The transversely lengthened convex terminal surface measures 11 inches along the curve. Originally its length was somewhat greater; for a small piece of its front (outer) end is wanting. Its posterior end,

* The terms anterior, posterior, upper, and under indicate the directions of the borders and surfaces when the axis of the bone is supposed to lie in a nearly horizontal plane, and nearly perpendicular to the axis of the trunk.

† The term "epiphysis" is used here in a modified sense. "Dans les crocodiles et les tortues, les extrémités des os et leurs principales éminences sont enduites de cartilages plus ou moins épais, qui durcissent et s'ossifient avec l'âge, mais dans lesquels il ne se forme point, comme dans les mammifères, de noyau osseux, séparé pendant quelque temps du corps de l'os ou de la diaphyse par une suture; circonstance d'autant plus singulière, que les sauriens, spécialement les monitors, ont à leurs os longs des épiphyses très-marquées."—Cuvier, *Ossemens de Reptiles*, 1824, viii. p. 8.

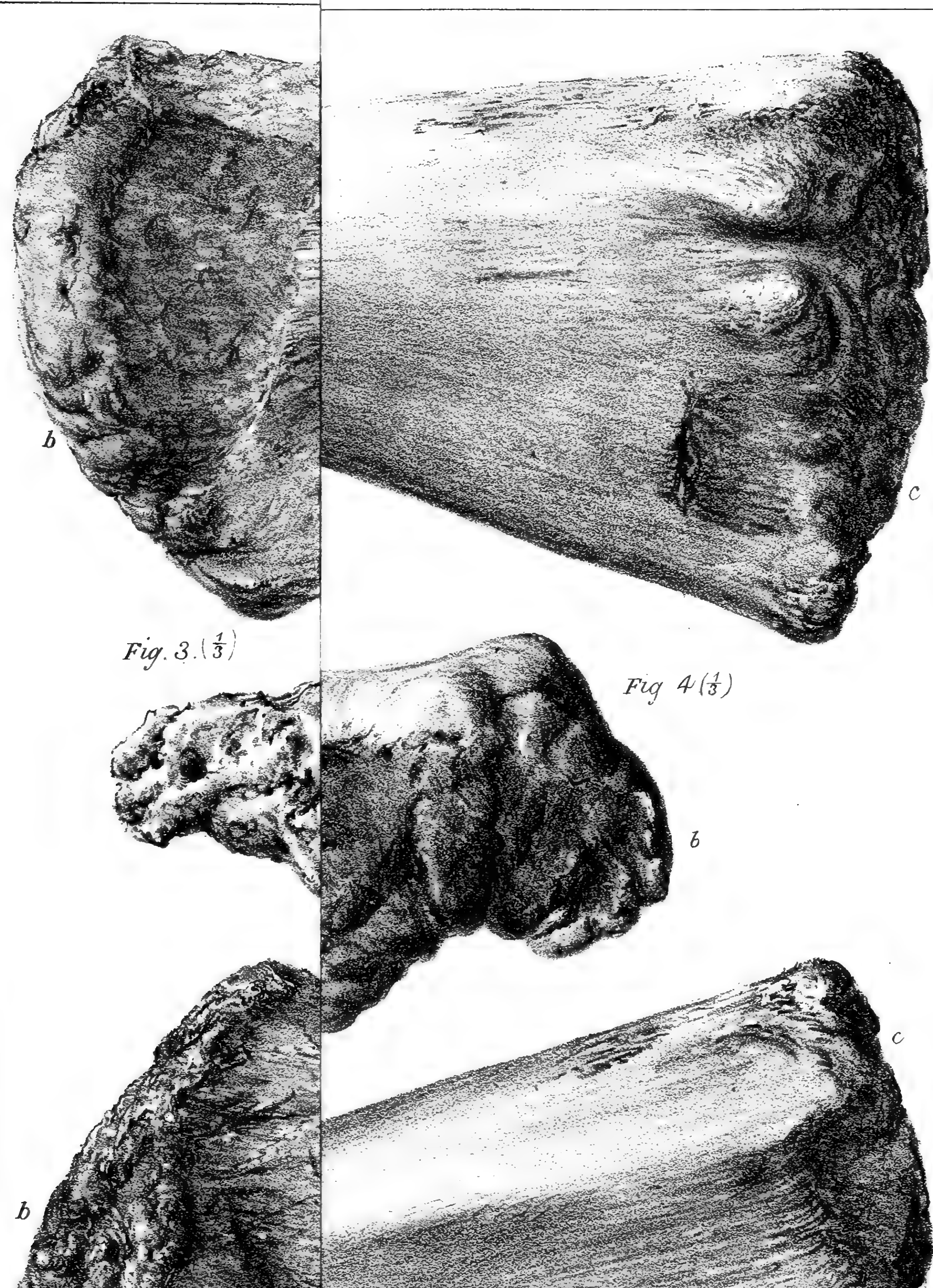
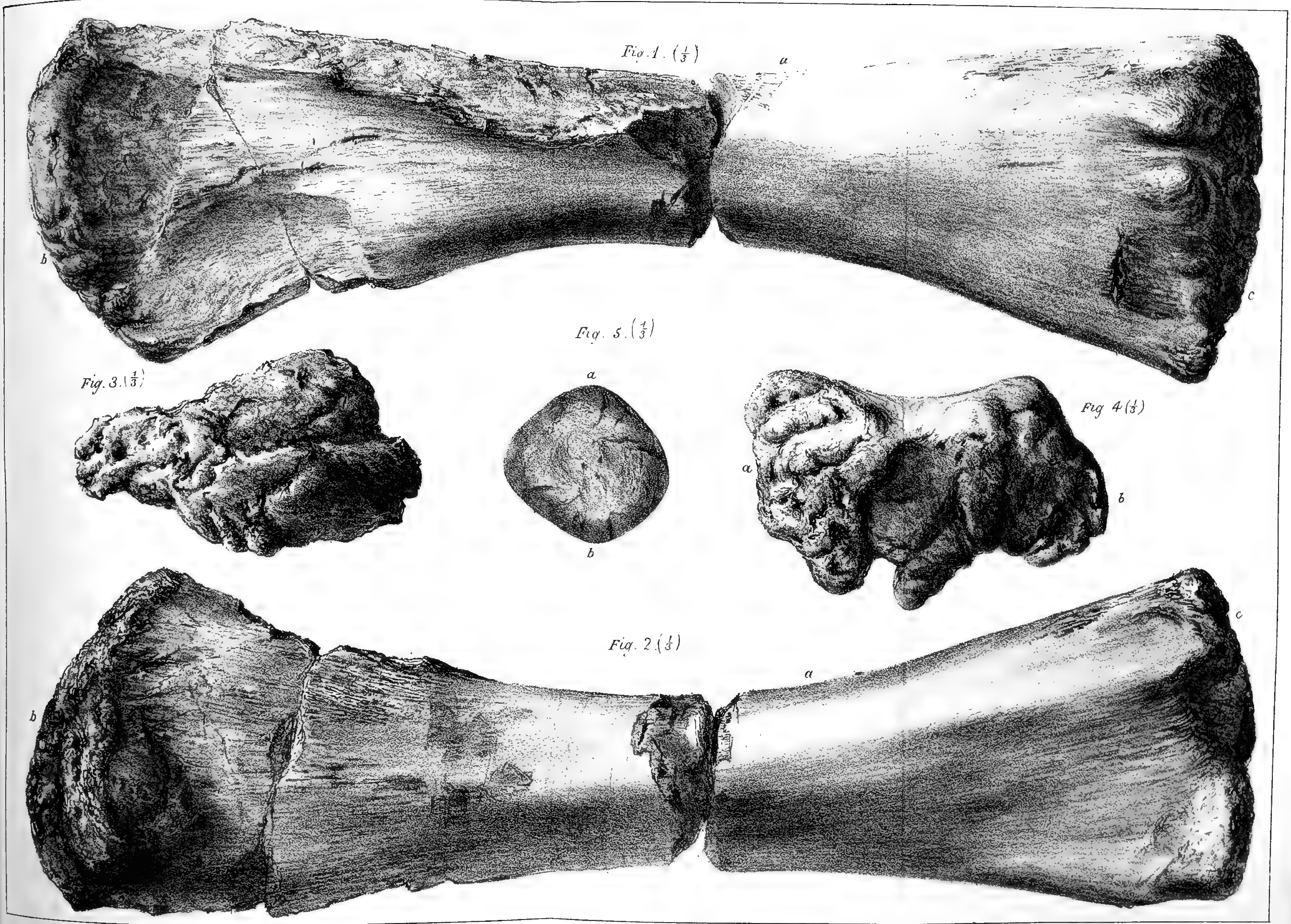


Fig. 3. (1/3)

Fig 4 (1/3)

E. Fielding lith.

M. & N. Hanhart imp.



E Fielding lith.

M & N Hanhart imp

SAURIAN HUMERUS FROM KIMMERIDGE

uninjured, forms a prominent rounded angle with the corresponding posterior (inner) border of the extremity. Here it has a width of 1 inch, which increases to 4·5 inches at the summit of the curve (the increase being chiefly caused by a swelling of the upper surface of the extremity, the terminal aspect of which is separated by a groove from the rest of the terminal surface), whence it again diminishes to 1·5 inch near the anterior (outer) missing angle. The under (anterior) surface is generally flat, with a slight longitudinal and transverse hollowing of its posterior (inner) half. The upper (posterior) surface is transversely slightly convex for 1·8 inch from its posterior (inner) border, then slightly hollow for another inch; and from this to within a short distance of its anterior (outer) margin it is rendered strongly convex by the large subpyramidal swelling just mentioned, the base of which forms part of the terminal surface.

Distal extremity.—This is much more massive than the proximal end. Its form is somewhat cubical. The terminal surface is flatter and of an oblong figure, divided into a couple of condyles by a depression in its upper (posterior) border, and by two angular excursions of its lower (anterior) margin. The posterior (inner) condyloid surface is the larger one. The upper surface exhibits a broad, shallow, longitudinal, median groove, 5 inches wide at the edge of the terminal surface, growing narrower as it recedes from this, and dividing at about 8 inches distance from it to receive the distal end of a low median ridge prolonged from the shaft. The anterior (outer) branch of this hollow ends about 1 inch sooner than the posterior (inner) one. On the under (anterior) surface two strong subpyramidal swellings ·9 inch high, corresponding to the two excursions mentioned in the lower (anterior) border of the terminal surface, and, indicating the greater projection of the condyles in this direction, immediately arrest the eye. The anterior (outer) swelling, with a base 1·8 inch wide at the terminal border, begins to rise at 1 inch from the anterior (outer or radial) border of the extremity. A deep intercondyloid notch, ·8 inch wide, separates it from the posterior (inner) swelling of nearly the same size and form. Between this and the posterior (inner or ulnar) border of the extremity the surface is first longitudinally grooved by a shallow depression which has been slightly increased by compression, and then gently convex. The anterior (outer) and posterior (inner) margins are so broad and flat near the terminal border, that here they might be properly called surfaces; but towards the shaft they grow narrower and become transversely convex.

Shaft.—Of a subcylindrical form, this comprises about the middle third of the bone. Its upper (posterior) surface is strongly convex transversely. The under surface is transversely convex in its posterior (inner) half; but it has a shallow longitudinal median hollow, widening towards the proximal extremity, and merging into the shallow depression mentioned in the posterior half of the under surface of this. The anterior (outer) border of this longitudinal hollow rises sharply, as if it were the beginning of a deltoid crest.

Contour.—When the bone is placed horizontally the outline of the upper surface falls gradually from the proximal end, rises slightly over the shaft, and then again gently declines along the upper intercondyloid groove.

Remarks.—The general configuration of this bone (particularly the form of its extremities, and especially that of its proximal one) proves it to be reptilian, and at the same time separates it from the Enaliosauria, the remains of which are so common in the Kimmeridge clay of the Dorset coast.

A comparison of it with several humeri and femora of recent crocodiles and lizards leaves no doubt in my mind that it is the left humerus of a crocodilian; but its axis is less twisted and its proximal end has a smaller upward curve than the humerus of now living crocodiles, from which it also differs in its enormous size. This last character also removes it from the extinct Crocodilia, the Teleosaurs and Stenosaurs, from *Goniopholis* and *Poikilopleuron*, none of which, so far as they are yet known to us, had humeri approaching the magnitude of this bone. There are three genera to the individuals of which a stature correlative with the size of this Kimmeridge humerus has been assigned—*Streptospondylus*, *Cetiosarus*, and *Polyptychodon*. Not anything, so far as I can learn, seems to be known of the limb-bones of *Streptospondylus major*, Owen; but those of *Polyptychodon* and *Cetiosaurus* are described as having a coarse spongy texture, and as being destitute of a medullary cavity.

The evidence on which these statements rest, so far as it has been accessible to me, does not appear to my mind to be decisive regarding these two points. The portions of long bones referred by the late Dr. Mantell to *Cetiosaurus*, formerly in his cabinet, and now in the British Museum, are so fragmentary that, in the absence of any record of their discovery in immediate association with vertebræ of the recognized Cetiosaurian type to authenticate them, the correctness of their reference to this genus is open to doubt; and there is the same uncertainty respecting the large bone in the Oxford Museum provisionally assigned to *Cetiosaurus*, and also with regard to the great Hythe saurian assigned by Prof. Owen to *Polyptychodon*.

It must be conceded that the limb-bones of these two genera have not yet been certainly identified; and therefore statements regarding their structure can be of little value.

So far as relates to the absence of a medullary cavity, this Kimmeridge humerus agrees with what has been published of *Polyptychodon* and *Cetiosaurus*; but it completely differs from them both in the compactness of its tissues.

It is also unlike the humeri of the Dinosaurs, *Iguanodon* and *Hylæosaurus*; and, so far as the material within my reach has enabled me to judge, it is not like that of *Megalosaurus*; but the bones in the British Museum considered to be humeri of this saurian are too fragmentary for the comparison with them to be final.

The bone with which in its general features it agrees more closely than with any other known to me, is one formerly in the late Dr. Mantell's collection and now in the British Museum. It was regarded by Dr. Mantell as a right humerus (an opinion adopted by

Owen), and it is the bone on which Mantell founded his genus *Pelorosaurus*. But the agreement is not complete; for, besides the much greater size of the Pelorosaurian humerus, which cannot be altogether explained by assuming the bones to have belonged to individuals of different ages (because the smoothness and compact texture of the Kimmeridge bone, and the absence of the large and numerous vascular foramina so conspicuous near the articular end in young and growing crocodiles, show it to have belonged to an adult animal), there are variations of details, amongst which I may cite the very different form of the transverse sections of the shafts and the presence of a medullary cavity in *Pelorosaurus*.

We have, then, in this humerus evidence of the existence during the Kimmeridge period of an immense saurian fitted for terrestrial progression, with strong crocodilian affinities, but differing from any yet completely known to us; of such a gigantic saurian we had already traces in a great ungual phalanx from the Kimmeridge clay of Ely and a fibula from near Weymouth, both in the British Museum, and in a cast of a large tibia also in the same collection, the original of which I think I have seen in the Woodwardian Museum labelled "*Macrochelys*"*.

Measurements.

	inches.
Length	31
Girth of shaft at *a*	13
Proximal end:—	
Length of terminal surface along the curve	11
Maximum width of terminal surface	4·5
Width near anterior angle	1·5
„ at posterior angle	1
Girth	21
Direct line between anterior and posterior angles of terminal surface	8
Distal end:—	
Girth	24
Transverse diameter of terminal surface	9
Width (from upper to under surface) of posterior condyle	5
„ of anterior condyle	3·5
„ at intercondyloid notch	3

EXPLANATION OF PLATE XVI.

Left Saurian humerus from Kimmeridge Bay. In the Collection of J. C. Mansel, Esq.

[The fractions annexed to the figures indicate the extent of the reduction from the natural size.]

Fig. 1. Under (or anterior) surface: *a*, anterior (or outer) border; *b*, proximal end; *c*, distal end.

2. Upper (or posterior) surface: *a*, posterior (or inner) border; *b*, proximal end; *c*, distal end.
3. Proximal terminal surface.
4. Distal terminal surface: *a*, anterior; *b*, posterior end.
5. Transverse section of shaft, showing the absence of a medullary cavity: *a*, anterior, *b*, posterior surface.

[* Mr. Seeley informs me that the name of "*Gigantosaurus megalonyx*" has now been attached to this specimen.—W. S. D.]

3. *Notes on some* Fossil Remains *of a* Gavial-like Saurian *from* Kimmeridge Bay, *collected by* J. C. Mansel, Esq., *establishing its identity with* Cuvier's Deuxième Gavial d'Honfleur, *Tête à museau plus court* (Steneosaurus rostro-minor *of* Geoffroy St.-Hilaire, 1825), *and with* Quenstedt's Dakosaurus. By J. W. Hulke, Esq., F.R.S., F.G.S.

[Plates XVII. & XVIII.]

The fossils which form the subject of this note consist of part of a lower jaw, with teeth and vertebræ, imbedded in hard pyritic claystone, lent me by J. C. Mansel, Esq., and of parts of the upper and lower jaws, with several teeth *in situ* and loose, portions of vertebræ and of ribs, a femur, and some other bones, which, owing to their fragmentary and crushed condition, I have not been able to identify, in the British Museum.

As received from Mr. Mansel, the bones in the British Museum were nearly hidden in large masses of very hard stone containing, as is usual in Kimmeridge fossils, much pyrites, which made it very difficult to extricate them; but this has been successfully accomplished, and the severed pieces have been very skilfully joined by Mr. Davies, to whom I am glad to take this opportunity of expressing my obligation for much valuable assistance.

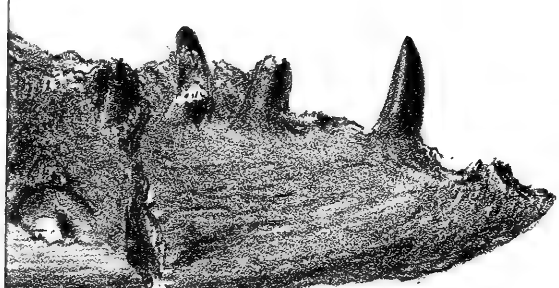
Description—Upper Jaw.—Of this the British Museum has the extreme end of the snout, comprising the symphysis, with about 4 inches of both intermaxillæ, forming the antero-lateral boundary of an undivided terminal nostril, which has a laterally compressed oval form, and is not swollen at the sides as in the living Gavials and in the extinct Teleosaurs. The oval nostril is indented in front by a slightly overhanging, medial, tubercular production of the symphysis. A thin seam of stone marks the open intermaxillary suture. The outer border of the upper surface of the portions of the intermaxillæ bounding the nostril makes a blunt ridge with the nearly vertical outer surface, from which the upper surface slants inwards and downwards to the inner surface; and this latter slants downwards and outwards, so as to overhang the floor of the nostril, with which it makes an angle of rather more than 45°.

The alveolar border of the right intermaxilla has been laid bare; it contains three alveoli; and the hard palate has been traced to within ·9 inch of the symphysis, which shows that the palatine processes of the intermaxillaries subtend the greater part of the nostril, and that the prepalatine foramen is proportionately lessened, a point of resemblance to the living Gavial in which this latter differs from crocodiles proper. The outer surface of the intermaxillæ bends evenly outwards and backwards from the symphysis. There is not any indication of a notch for the passage of the fourth tooth; and, as far as I can judge from this fragment, the snout tapered regularly, ending bluntly.

There is another fragment, $5\frac{1}{2}$ inches long, which belongs, perhaps, to the upper maxilla. It contains five alveoli, four of which include portions of teeth. The outer surface is moderately convex;

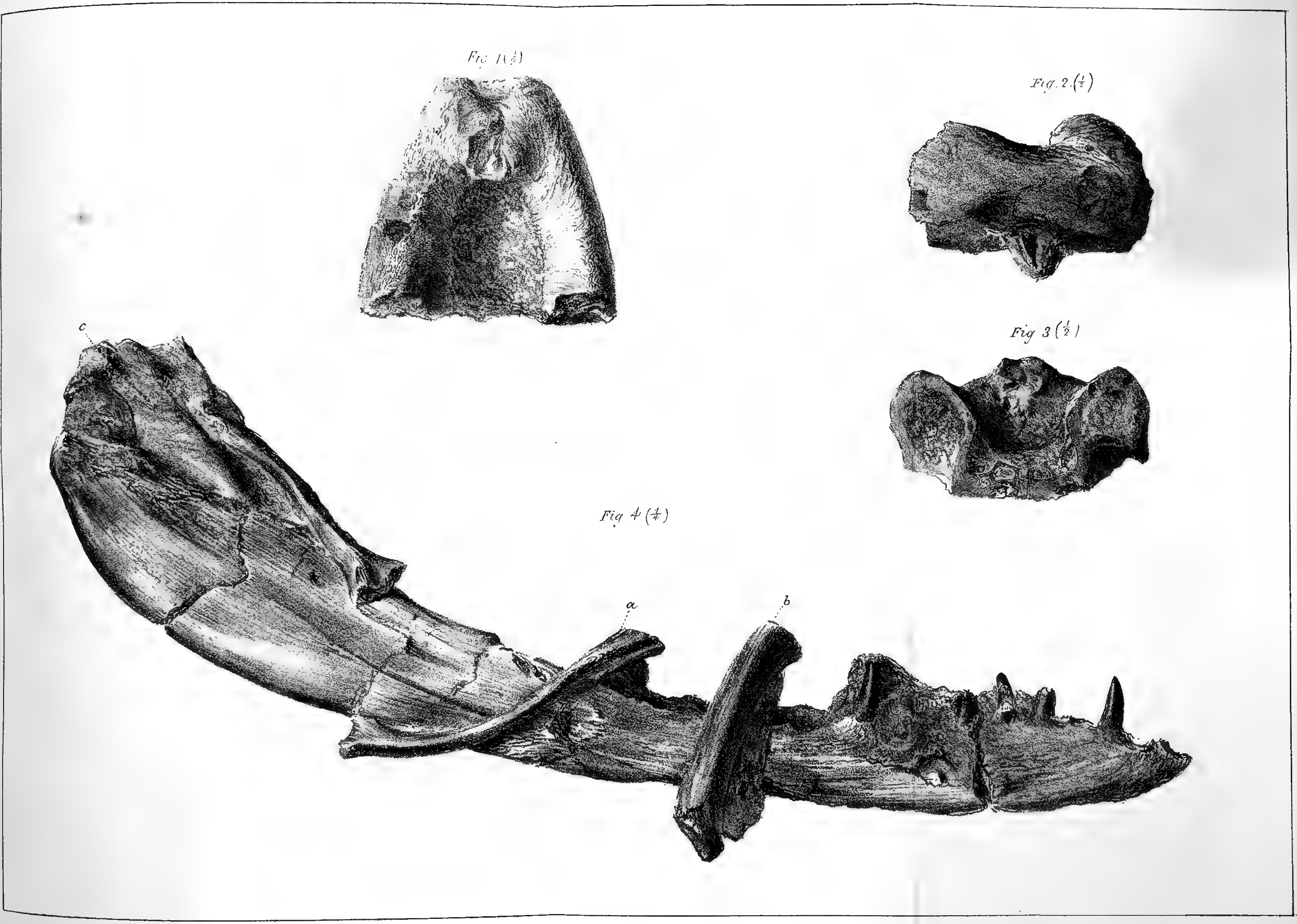
Fig. 2. (1/2)

Fig 3 (1/2)



F. Fielding. lith

M & N Hanhart. lith



F. Fielding. lith

M&N Hanhart lith

STENEOSAURUS FROM KIMMERIDGE

Fig. 1. ($\frac{1}{2}$)

Fig. 2. ($\frac{1}{2}$)

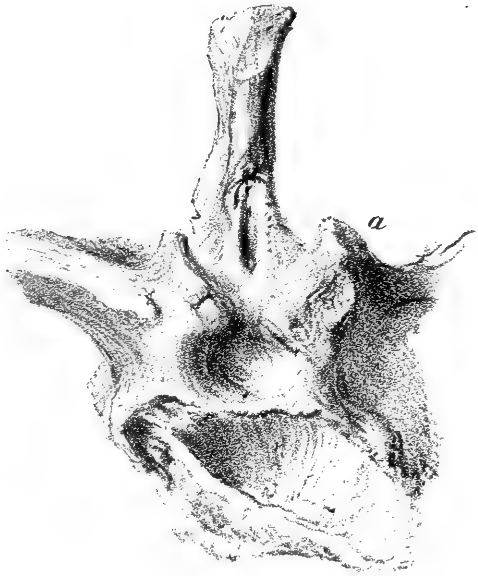


Fig. 3. ($\frac{1}{2}$)

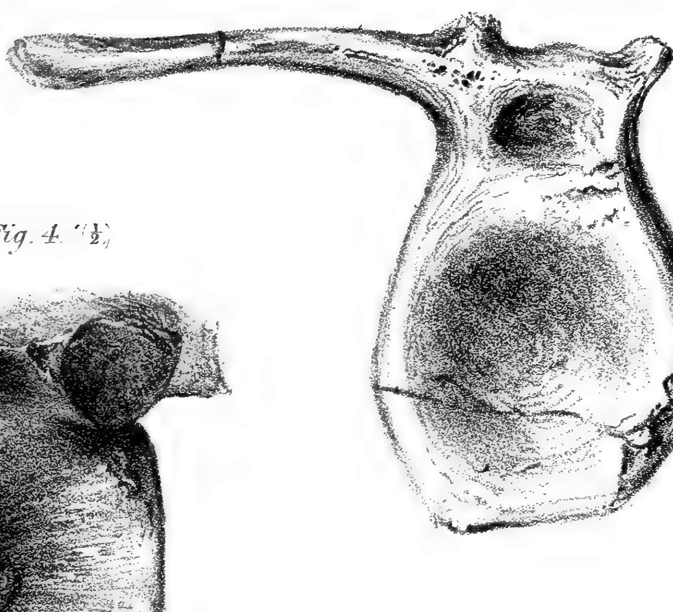
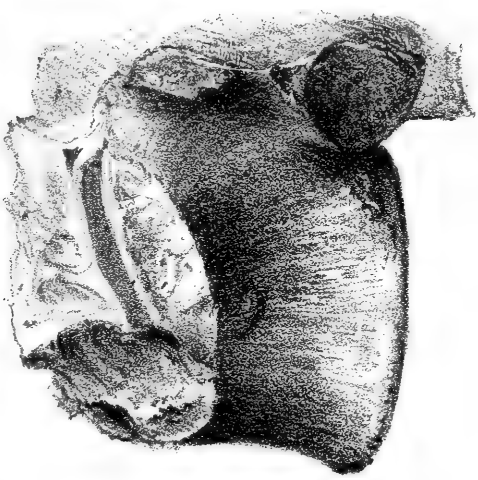


Fig. 4. ($\frac{1}{2}$)



Fielding lith. M & N Hanhart imp

STENEOSAURUS FROM KIMMERIDGE.

the inner surface is less convex transversely than the outer, and bears a deep longitudinal groove. The buccal surface is longitudinally flat, and it rises gently towards its inner border, which makes it slightly hollow transversely. The outer surface of both fragments is smooth; it has a close grain, and a fine longitudinal striation.

Dimensions of the Anterior Extremity of the Upper Maxilla.

	inches.
Antero-posterior diameter of symphysis	1·8
Maximum vertical depth of symphysis	2·3
Length of fragment of intermaxilla	4
Diameter of first and second alveoli in right intermaxilla	1·1
Width of nostril at level of its floor at posterior surface of fragment	1·8
Width of nostril at angle where the inner and upper surfaces of intermaxilla meet	1·5
Maximum width of nostril at angle where upper and outer surfaces meet	3·1
Vertical depth of intermaxilla at posterior surface of fragment	1·9
Transverse diameter of intermaxilla at junction of upper and inner surfaces	1·3
Do. do. at floor of nostril	1·65
Max. vert. depth of nostril from its floor to meeting of upper and outer surfaces of intermaxilla	0·95
Breadth of snout just behind symphysis	3

Lower Jaw.—In the British Museum there is now, stripped of its matrix, in continuous fragments, which have been cleverly joined by Mr. Davies, a nearly complete right ramus, including the entire non-tooth-bearing part, measuring 30 inches from its posterior extremity to the hindermost visible tooth*, with 4 inches of the tooth-bearing part. Viewed from above, the dentary part, with 4 inches of the ramus behind it, appears to be nearly straight, and from this point the ramus curves outwards nearly to its posterior extremity, where it becomes slightly inflected. When the straight, toothed part is placed horizontally, the ramus behind it is observed to have a large upward curve. The upper border of the jaw, traced from behind forwards, exhibits first a gently inclined, slightly longitudinally hollowed and transversely flat postarticular surface, 2·7 inches long, separated by a transverse ridge from a longitudinally concave articular surface of nearly equal length, which looks forwards and upwards. From this the border declines gently for about 5 inches,

* The upper surface has been more recently cleared of the matrix behind the tooth, exposing four more alveoli, which, with two, for which there is ample space in an intermediate fragment on which the distal end of the femur lies, make six, or perhaps seven, teeth behind the point where the symphysis probably begins, and lessens the length of the non-tooth-bearing ramus to between 22 and 23 inches.

where, at 7·5 inches from the postarticular ridge, it makes a coronoid eminence, which is less elevated than that of lizards, but which rises more than that of crocodiles. From this onwards the border sinks at first in a rather steep curve, and then runs forwards nearly horizontally to the straight dentary part.

The lower border of the ramus sweeps downwards and forwards from the posterior extremity in a nearly uniform curve to about 6 inches behind the hindermost tooth, from which point onwards it is nearly straight. Six inches from the posterior extremity, and 4 inches behind the coronoid process, the curve is broken by a distinct angle.

The form of the toothed part may be roughly compared to a three-sided prism. The upper surface is nearly flat, and its inner border rises slightly higher than its outer border, which is pierced by the alveoli at short intervals. The inner surface is vertical. It is scored by furrows and striæ, which begin a little distance in front of the angle which the straight part makes with the curved part of the jaw, and which mark, I think, the beginning of the symphysial suture. The outer and under surface, much defaced, is transversely convex. Behind the straight dentary part, the ramus loses in thickness, and at about 6 inches from the last visible tooth it begins to gain in depth, while the inner and outer surfaces becoming parallel, the transverse section has here an oblong figure. From this backwards the depth of the ramus increases till it attains its maximum in the coronoid eminence, behind which it declines to the posterior extremity.

The large vacuity in the outer surface, between the angular, surangular, and dentary bone, present in all living crocodiles, and, as far as I can learn, in all extinct ones of the Tertiary period, is entirely absent from this Kimmeridge jaw, in which the component bones meet closely. For about 16 inches from the posterior extremity, the outer surface is nearly equally shared by the angular bone below, and an upper splint comprising, I suppose, the dentary and surangular, with a small portion of the articular bone. About $1\frac{1}{2}$ inch in front of the postarticular ridge, and therefore just at the front of the articular surface, on the upper border, there is a fissure filled with stone, which may be the suture between the articular and surangular bones; but I cannot trace any suture marking the respective shares of the surangular and dentary bones, unless a fissure running along the bottom of a groove which indents the surface of the jaw, parallel with its upper border, for 7 inches forwards from the coronoid eminence, be part of it, of which I feel very doubtful. This composite surangular and dentary splint, with the articular, forms the upper border and the greatest part of the posterior extremity of the ramus. From this latter to a short distance in front of the articulation, the natural surface of the bone has suffered from chipping, and is quite destroyed here; but it reappears in front of the articulation, and it exhibits, for about 12 inches, a fine longitudinal striation; the striæ spread from a point in the lower border of the splint, below the articulation, in a fanlike manner, the lower ones coursing parallel to this border, while the upper lines radiate towards the coronoid process. The angular bone forms the lower half of the hindermost 16 inches of the ramus, and completes the posterior extremity. It composes the whole lower border of the ramus for about 25 inches, and it is also visible on the inner surface, below the articular bone, from which in this situation it is marked off by a suture, which, further forwards, a couple of inches in front of the salient anterior internal angle of the articular bone, becomes lost in the matrix. In the outer surface a conspicuous suture, nearly straight for the first 9 inches from the posterior extremity, and then curving downwards for the next 15 inches, separates the angular bone from the dentary and surangular bone above it. The anterior two-thirds of the angular bone are also longitudinally striated; and the uppermost striæ run out obliquely at the upper border of the bone, which helps to increase the distinctness of the suture between it and the surangular. On the inner side, the anterior internal angle of the articular bone projects strongly 3 inches above the lower border of the ramus, and nearly 6 inches from its posterior extremity; its anterior margin descends at first almost vertically, and then curves forwards to the suture with the angular bone. In front of this the inner surface is hidden for nearly 4 inches by large splints of bone lying athwart it, which are, I think, pieces of the upper jaw*; and for 6 inches in front of these it is much defaced; but beyond this, to the dental part, it is smooth, and channelled by a broad, shallow, longitudinal groove. The splenial bone is wanting.

The piece of the lower jaw lent me by J. C. Mansel, Esq., consists of 7 inches of the anterior extremity of the right half. The lower and upper lines meet in rather a blunt point. The outer surface, transversely convex, is beset with a few vascular foramina below the two first alveoli. The inner, vertical surface is scored with marks of the symphysial suture. The upper surface is horizontal and flat, rising slightly towards the inner border; its outer third is pierced by the openings of six sockets, from the four last of which fully grown teeth protrude. The sections which Mr. Mansel has most kindly allowed me to have made†, show clearly the loose implantation of the long tooth-fangs in capacious alveoli, which have a forward and outward inclination that gives a corresponding slant to the teeth. The alveolar apertures in the border of the dentary bone are quite distinct from one another. They are here separated from each other by very evident unbroken partitions, which, however, are less complete in the in-

* These splints have been further exposed since the above account was written; they are portions of both maxillæ crushed and retroverted, so that the front end overhangs the posterior extremity of the ramus of the lower jaw. The nasal bones are absent; but the groove into which they were received reaches forwards for a considerable distance on the upper and inner edge of the maxillary bones.

† For getting these sections made I am under great obligation to Mr. Etheridge.

terior of the jaw-bone, owing to the increasing dimensions of the tooth-roots towards the bottom of the alveoli.

Dimensions of Lower Jaw.

Right ramus.	inches.
Length from posterior extremity to the hindermost visible tooth	30
Length of articular surface measured from its ant. int. angle to the postarticular ridge	2·7
Length of postarticular surface	2·7
Distance of coronoid process from the postarticular ridge	7·5
Horizontal distance between coronoid process and angle	4
Distance of angle from posterior extremity of jaw	5
Depth of jaw at angle	4·5
„ at coronoid eminence	6
„ at articular surface	3·5

Teeth.—Of these several are *in situ*, some have fallen out of their sockets and lie scattered in the matrix, and others are loose. They vary much in size and in length, but they may very properly be called slender and tapering. They are slightly incurved, and curved slightly backwards. In the fully grown teeth, a long root or fang buried in the alveolus, a long, tapering, enamelled crown, and a relatively long intermediate neck without enamel are distinguishable.

The fang is subcylindrical. Some have a slight lateral compression, giving to their cross section an egg-shape—the smaller end turned backwards. They have a remarkably large, conical pulp-cavity, open below, and ascending through the neck a long distance into the crown. Their outer surface is finely striated longitudinally, and it is distinguished by its light brown colour and by its want of polish from the highly polished deep madder-brown crown. This latter is laterally compressed, unequally convex, the outer surface being less swollen than the inner; it is also two-edged, and the edges, which are back and front, are finely notched. In a strong light, the serrature is recognizable by the unaided eye, and it is always distinctly perceptible to the touch.

The posterior edge begins rather earlier than the anterior on the neck of the tooth; and the first two or three lines are unbroken. A shallow marginal depression of the outer surface runs parallel to the notched edges. The highly polished crown is overlaid with very fine, closely-set, longitudinal striæ just visible to the unaided eye in a good light, the striæ scarcely rising above the surface. On the more convex inner surface a few broader, widely set, parallel striæ are prolonged from the lower limit of the enamel for some distance upon the crown, but they do not reach its top. Some of the crowns are marked with faint annular indentations.

Succession of the Teeth.—The presence of the germ of an immature crown in the pulp-cavity of a fully-grown tooth, the occurrence of an annular fragment of a former fang around the fang of an effective tooth in one of the alveoli, and the protrusion of a small immature tooth from a very wide alveolus demonstrate that, as regards the manner of succession of its teeth, this Kimmeridge crocodile agreed with those of our day.

Minute Structure of the Teeth.—This so agrees substantially with that of living crocodiles that any description of it is superfluous.

Vertebræ.—All the vertebræ which have as yet been brought into view are amphicœlian; both articular faces are moderately but decidedly hollow. The centrum is cylindrical. Its middle is constricted, laterally compressed, and overhung by the expanded articular ends, which have a nearly circular contour. In two of these vertebræ the posterior articular face has a rather longer vertical than transverse diameter, due, I think, to squeezing. The neurapophyses, laterally compressed and thin, are suturally attached to the upper surface of the centrum in nearly its whole length, reaching, however, nearer to the anterior than to the posterior margin. The suture descends slightly on the side of the centrum. The neural canal is indented by a median groove, deepest at its middle, as is common in some crocodiles.

One of the vertebræ, imbedded in the same mass of stone as the ramus of the lower jaw in the British Museum, has a costal facet on the anterior margin of the transverse process (diapophysis), near its root, and none on the centrum, which makes it correspond to the fifth or sixth thoracic vertebra of living crocodiles, from which, however, it differs in the absence of a hypapophysis, as well as in its hollow articular faces. Beyond this costal facet the process has been unfortunately broken off; its section is trihedral; but the right transverse process is 3·5 inches long. The posterior border of the neural spine, the only part of it visible, is ·5 inch thick, and 2·5 inches long, and it ends abruptly as if squarely truncated. The postzygapophyses are very mutilated, they project backwards from the neurapophysis, their lower ends nearly meeting in the level of the crown of the neural canal, and their upper ends diverging. Their surfaces look outwards and downwards. In another vertebral arch with the spine and transverse processes, which, from the great length of these latter, together with the absence of a costal facet from their anterior margin, I presume to be part of a posterior thoracic vertebra, the prezygapophyses project from the front of the neurapophyses just above the plane of the anterior margin of the diapophyses. The size and form of their surface are hidden; but their anterior margin is part of a very wide curve, and it has a more nearly upward direction than in the more anterior vertebra.

Measurements of vertebræ.	In British Museum.					
	No. 1. In block with ramus of lower jaw.	No 2. In same block.	No. 3. In block with symphysis of upper jaw.	No. 4. Arch with processes and spine, centrum wanting.	No. 5. In block with anterior extremity of lower jaw.	No. 6. Do., lent me by Mr. Mansel.
	inches.	inches.	inches.	inches.	inches.	inches.
Height from lower border of centrum to end of neural spine...	5·8					
Centrum.						
Posterior articular face.						
Breadth	2·5	....	2·6	....	....	2·5
Height	2·6	....	2·6	....	....	2·9
Anterior articular face.						
Breadth	....	....	....	....	2·5	2·8
Height	....	....	....	....	3·1	2·8
Length	3·1	....	2·8	....	3·1	2·9
Transverse horizontal diameter midway between neurap. suture and inf. median line ...	1·6					
Neurapophysis.						
Length						
Thickness						
Diapophysis.						
Length	3·5	....	....	....	....	4·5
Breadth at root	2·1	....	....	2·3		
Thickness of ant. margin ...	0	....	....	·3 to ·4		
,, post. margin...	·9	....	....	·9 to 1		

Ribs.—Imbedded in the same blocks of stone with the vertebræ and jaws are fragments of several ribs. The longest of these, 12 inches long, lies across the outer surface of the lower jaw. For 10 inches it is cylindrical; and it has an average diameter of ·8 inch. Its distal end is flattened; the flatness may have been slightly increased by squeezing, as the texture of the bone shows here signs of crushing. Its vertebral end is forked, and some of the other fragments are also distinctly bifurcated; but in none are the actual articular surfaces preserved.

Limb-bones.—The only limb-bone which I can identify is a long bone, the distal half of which is seen lying across the lower jaw. Its proximal half has been exposed in the reverse side of another block, so that, very unfortunately, the entire bone cannot be viewed at once. The broken ends, however, fit accurately, and there cannot be the slightest doubt of the original continuity of the two pieces. This bone agrees more closely with the femur of the living crocodile than with the humerus of this latter; and on this ground I believe it to be the femur, the left one. In its present state it is 14 inches long. The proximal end is expanded transversely, and it measures 3 inches across. Its under surface bears a subhemispherical articular head, below which is a slight swelling, which I take to be the traces of a crushed and worn trochanter. The shaft has been much squeezed. All the fractures show that the interior consists of cancellous tissue, which, in some situations, has a very open texture, without, however, there being strictly any medullary canal. The axis is very slightly twisted, much less, I think, than in existing crocodiles. The line of the anterior border of the shaft is convex, and that of the posterior border correspondingly hollow. The distal end is much damaged, but traces of one condyle are recognizable.

Dimensions of Femur.

	inches.
Length in its present mutilated state	14
Proximal end. Breadth	3
Transverse diameter of articular surface	2·1
Longitudinal diameter of ditto....................	1·6
Diameter of shaft at centre	2
" " near distal end	2

These diameters are from back to front; those from upper to under surface are less.

Conclusions.—The conclusions resulting from my examination of the fossil remains of this Kimmeridge Saurian are:—

I. That it is an amphicœlian Gavial-like crocodile.

II. That it is probably identical with Cuvier's 2nd Honfleur Gavial, "*tête à museau plus court*," to which Cuvier assigned vertebræ of his "*système convexe*;" *Steneosaurus rostro-minor* of Geoffroy Saint-Hilaire, 1825; *Metriorhynchus*, Von Meyer, 1830, who reversed Cuvier's disposal of the vertebræ, and gave those of the "système concave" to the short snout; *Steneosaurus*, Owen, 1841, who adopted Von Meyer's allotment of the vertebræ; *Streptospondylus*, Von Meyer, 1847, who returned to Cuvier's association of the opisthocœlous vertebræ with the "tête à museau plus court;" *Metriorhynchus*, Bronn, 1851.

III. That it is also identical with *Dakosaurus*, Quenstedt.

IV. That *Dakosaurus* is probably Cuvier's second Honfleur Gavial "tête à museau plus court."

I now proceed to establish these points *seriatim*:—

I. That this Kimmeridge Saurian is an amphicœlian Gavial-like crocodile is proved beyond doubt by its bifurcated (anterior) ribs, the long transverse processes of the posterior thoracic vertebræ, the sutural attachment of the neurapophysis to the centrum, the concavity of both articular faces of this latter, the nature of the attachment of the teeth and the manner of their succession, the restriction of the teeth to the symphysial part of the jaw and a very small piece of the adjoining ramus, the relatively long symphysis, and the single undivided terminal nostril.

II. It is probably identical with Cuvier's second Honfleur Gavial, "tête à museau plus court."

In order to make this clear I must first cite briefly those facts relating to the Honfleur Gavials which bear directly on this matter.

They are found in the 'Annales du Muséum d'Histoire Naturelle,' t. xii. article iv. pp. 88–101 (Paris, 1808), and in the 'Ossemens Fossiles,' t. v. partie ii. article iv. p. 143 (5th ed., Paris, 1826).

In a collection of fossil bones from the neighbourhood of Honfleur, made by the Abbé Bachelet, and afterwards transferred to the Museum of Natural History, Paris, Cuvier recognized parts of the upper and lower jaws of two species of Gavials, differing from all recent and extinct ones then known, and also vertebræ of two kinds. The least-mutilated lower jaw comprised the entire dentary portion, with the greater part of both rami. The composite character of the jaw, its teeth, and the manner of their implantation and of their succession demonstrated the crocodilian nature of the fossil. In its long symphysis and in the restriction of the teeth to this part of the dentary bone, Cuvier saw resemblances to the Gavial; but he also perceived that the Honfleur Gavial differed from the Gangetic in the relatively greater length of the ramus, in the smaller angle included by the rami at the symphysis, in the more regularly tapering form of the head, and in the absence of the oval hole present in the outer surface of all known living crocodiles. Cuvier does not give a very detailed account of the teeth; but he mentions that they are conical and striated, and have "deux arêtes tranchantes." (Figs. 1 & 2, pl. viii. Oss. Foss., are upper and side views of this lower jaw.)

To this lower jaw Cuvier confidently allotted the fragment of an upper jaw comprising the symphysis with part of both intermaxillaries containing three alveoli and forming the front of the external nostril. (Figs. 6 & 7, pl. viii., are upper and under views of this fossil.)

Cuvier's lower jaw wants the posterior extremities of the rami, while from the Kimmeridge jaw the middle of the dentary piece is absent. A comparison of its measurements with those of the Honfleur jaw given by Cuvier is therefore not possible; but in all the points in which a comparison can be instituted, the resemblance between the Kimmeridge and the Honfleur jaw is very close.

The Kimmeridge lower jaw, like the Honfleur (tête à museau plus court), has also a very long non-tooth-bearing ramus, which includes a larger angle with the straight tooth-bearing symphysis than does the living Gavial's; and this makes a sharper mandibular arch, indicative of a more uniformly tapering head, than the Gavial's. It also has not the oval hole in the outer surface which we find in all living crocodiles, and in all those, I think, of the Tertiary period. Its teeth, too, are conical, (very finely) striated, and they have "deux arêtes tranchantes."

Next, the likeness of Cuvier's upper view of the fragment of the maxilla of the "tête à museau plus court" (fig. 6, pl. viii. 'Ossemen's Foss.') to the corresponding view of the same part of the upper jaw of this Kimmeridge crocodilian is so striking that it is impossible not to recognize it.

This Honfleur fragment is very remarkable from the absence of bulging, and from the lateral compression of its terminal nostril.

The Kimmeridge snout has the same oval, laterally compressed terminal nostril in which the Honfleur "tête à museau plus court" differs from the Gangetic Gavials and the Teleosaurs; and taken by itself, I think its specific identity could scarcely be doubted by any one who compared it with Cuvier's figures 6, 7, pl. viii.; while if, when making the comparison, the strong resemblance of the lower jaw is borne in mind, the conviction that the individuals are specifically identical becomes irresistible.

That Cuvier rightly matched the jaws of his "tête à museau plus court" is now established by the conjunction of the jaws in this Kimmeridge fossil, which affords us another instance of the wonderful sagacity of this master in paleontology. The occurrence of amphicœlous vertebræ, and one of these probably the 5th thoracic, together with these Kimmeridge jaws is important, because it removes all doubt which of Cuvier's vertebral systems belongs to the "tête à museau plus court," and makes it evident that it is the "système concave"*.

III. The Kimmeridge crocodilian is identical with *Dakosaurus* of Quenstedt.

Inasmuch as the genus *Dakosaurus* was founded on teeth only, it is with those that the comparison between it and our Kimmeridge Saurian must be made.

Quenstedt's description of the teeth of *Dakosaurus* in 'Der Jura,' Tübingen, 1858, p. 131, was drawn from six teeth in a piece of jaw, probably the lower, 1 foot long; they are two-edged, serrated, unequally convex, subincurved, subretrocurved and implanted. He adds that he had formerly † described these teeth under the provisional name of *Megalosaurus*; and he points out that they differ from genuine Megalosaurian teeth in the greater compression, coarser serrature, and more sickle-like curvature of the latter. Further, Quenstedt identifies with his *Dakosaurus* the large tooth which Prof. Plieninger described in the 'Württemb. Jahresheft,' 1846, and represented in fig. 2, tab. 3. of this work under the name *Geosaurus maximus*, a name which Plieninger withdrew in 1849, on additional evidence that differentiated his Saurian from Sömmering's acrodont Geosuar ‡.

Our Kimmeridge teeth agree in every essential particular with those of Plieninger's *Geosaurus maximus*, and with those of Quenstedt's *Dakosaurus*. Plieninger's figures (fig. 2, Taf. 3), which are

* For a précis of the various views which have been entertained by later writers I must refer to Pictet's 'Paléont.' and Brown's 'Lethæa.' In face of the positive facts that "des vertèbres de la deuxième espèce (i. e. système concave) étaient pétrées dans le même morceau que la grande mâchoire inférieure, ce qui pourrait aussi engager à croire qu'elles venoient du même individu" (Ann. du Mus. t. xii.), it is very remarkable that Cuvier should have allowed speculation to prevail, and have assigned to this jaw the "système convexe en avant."

† *Cf.* "Flötzgebirg. Württemb." p. 493 in Handb. der Petrefakt., tab. 8, fig. 4.

‡ Cf. Württemb. Jahresheft, p. 252, tab. i. f. 7, 1849–50.

much more carefully executed than Quenstedt's, might have been drawn from one of our crowns, so complete is the resemblance.

The teeth of the Kimmeridge Saurian, like those of *Dakosaurus*, are slightly incurved, slightly backward-curved, laterally compressed, and unequally convex. They have a serrated front and back cutting edge, and they are finely striated. They are stouter than the teeth of *Megalosaurus*; their curve is also less sickle-like; and the serrature of their trenchant ridges is less coarse than that of this Dinosaur.

But, because comparison with actual specimens is more satisfactory than that with descriptions, however close to nature these may be, I have compared our teeth with other Dakosaurian teeth in the British Museum, and I have found them to be specifically identical*.

IV. That *Dakosaurus* is probably the same as Cuvier's "deuxième Gavial de Honfleur, tête à museau plus court," follows as the necessary consequence of the II. and III. of these conclusions, because, if this Kimmeridge crocodilian is identical with each of these, they must be identical with each other.

If these conclusions be ultimately proved correct, I would propose to retain Geoffroy St.-Hiliare's original name *Steneosaurus rostrominor*, to the exclusion of all given subsequently to his Memoir of 1825.

Note.—Since this paper was written, a further examination of the fossils presented to the British Museum has led to the discovery of a considerable part of the skull, with the complete snout, of this Kimmeridge crocodilian. I shall take an early opportunity of communicating a description of it to the Society.—J. W. H., Oct. 17, 1868.

EXPLANATION OF PLATES.

Plate XVII.

Fig. 1. Upper view of end of upper jaw of the Kimmeridge Gavial-like Crocodile, showing front half of subterminal nostril.
2. Side view of the same.
3. Posterior view of the same.
4. Outer view of right half of lower jaw of the same†. *a*, rib; *b*, part of the femur; *c*, part of the left half of the lower jaw, reversed. (This last I at first conjectured might be a crushed piece of the upper jaw.)

Plate XVIII.

Figs. 1 & 2. Side and front views of the neural arch and spine of a vertebra. *a*, prezygapophysis.
3. A trunk-vertebra, showing the anterior articular surface, the neural canal, and the long transverse process.
4. Side view of an early dorsal vertebra. There is a costal facet on the anterior margin of the transverse process near its root.

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* I greatly regret not to have had the advantage of seeing in print Mr. Mason Wood's paper on *Dakosaurus*, read in the early part of this session—the more so that, although present on the evening on which it was communicated to the Society, my mind being preoccupied by another subject, I did not give Mr. Wood's paper the attention it deserved.

† As the portions of this jaw entrusted to me by Mr. Mansel have been found to fit those in the British Museum, the jaw is shown in a single drawing after restoration.

Discussion.

Mr. Seeley remarked that in the base of the Oxford Clay, there was what he regarded as a peculiar form of *Dakosaurus*, with two serrated ridges close together on one side of the tooth, and one on the other. Vertebræ of similar character to those exhibited occurred in the Kimmeridge Clay at Ely, but the teeth were rarely perfect. The author's conclusions confirmed his own surmises.

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4. *On the* Geology *of a* Portion *of* Abyssinia*. By W. T. Blanford, Esq., F.G.S., Assoc. Roy. School of Mines, &c., late Geologist Abyssinian Expeditionary Force.

The geology of Abyssinia has been more or less examined by several eminent French and German travellers—Rüppell†, Roth‡, D'Abbadie §, Rocher d'Héricourt ||, and especially Ferret and Galinier ¶; but still there is very much left to be ascertained before the geological structure of the country can be said to be thoroughly known. The peculiar circumstances under which the late expedition was carried out limited the area of observation to the line of march from Annesley Bay to Mágdala; but along that line and, in some instances, in its immediate neighbourhood a very fair opportunity was afforded for judging of the general geological structure of the country, and of the relations of the most important rock-systems to each other. Roughly speaking, after passing the Posttertiary or late Tertiary volcanic rocks and alluvial deposits of the coast, the formations met with presented a regular ascending series as far as Mágdala, where the rocks belong to the highest group, with the exception of recent alluvial deposits, met with on the highlands.

After the departure of the expeditionary force, a few additional observations were made in Northern Abyssinia about Massowa, the Bogos country, and the Anseba valley.

The following are the formations which have been noticed in Abyssinia, in descending order:—

7. Recent.—Soils of the highlands. Alluvial deposits near the coast.
6. Posttertiary ?—Aden series of volcanic rocks.
5. Tertiary ? or Cretaceous ?—Bedded traps, basaltic and trachytic. Mágdala group.
4. Cretaceous ? or Jurassic ?—Bedded traps, chiefly basaltic. Ashángi group.
3. Jurassic.—Antalo limestones.
2. Infrajurassic (Triassic ?).—Adigrat sandstones.
1. ? ——————— Metamorphic rocks.

It is unnecessary to dwell on the physical geography, which has been already amply treated by numerous able observers. It is sufficient to remark that the portion of Abyssinia traversed is the dividing ridge between the salt plain to the eastward and the Nile valley

* The present is an abstract of the observations made, which will be published at length elsewhere. † Mus. Senckenberg. i. 286, p. 12.
‡ Münchn. gel. Anz. 1844, &c. § Bull. de la Soc. Géol. vol. x. p. 121.
|| Bull. de la Soc. Géol. 1846, p. 541; Compt. Rend. vol. xii. p. 732.
¶ Voy. en Abyss. vol. iii.

to the west, that the descent in the former direction is abrupt, in the latter gradual, and that from Senafé, where the force first reached the highlands, lat. 14° 40′ N., to south of Antalo (about 13° 10′) the country is comparatively entirely open, with but few ascents or descents of importance, of an average height of nearly 8000 feet above the sea, and composed principally of metamorphic rocks, limestone, and sandstone; whilst from a few miles south of Antalo the road traverses a succession of passes from 9000 to 10,500 feet above the sea, and the only rocks seen are volcanic, belonging to two distinct groups of bedded traps.

Metamorphic rocks.—These form the base of the greater portion of the Abyssinian plateau, if not of the whole. As usual, they vary to a very great extent in mineral character and degree of metamorphism, some being highly crystalline and even porphyritic granites, others mere slaty schists still exhibiting the original bedding. No reason was observed for dividing them into several groups; but it is possible and even probable that more extensive study would justify such division.

The direction of the foliation is very constant. From Af Abed in Habáb (lat. 16° 10′ N.) to about 25 miles south of Adigrat in Tigré (about 13° 50′), upwards of 150 miles, it rarely diverged more than a few degrees from due north and south. The dip is not quite so constant; but it is usually nearly vertical, though exceptions, probably due to disturbance, occur, at the base of the outer ranges especially. In the Anseba valley and around Keren in Bogos the strike of the foliation changes to north-east and south-west.

This strike is clearly due to cleavage, and not to original bedding; for in some very slaty rocks near Senafé the original bedding was observed crossing the foliation. The same might also have been inferred from the regularity of strike and high dip.

This strike corresponds with many important features of the country, such as the north and south ravines which cut through the outer ranges and tend to so great an extent to facilitate access to the highlands.

Adigrat Sandstone.—This is a massive sandstone, generally white in colour, of considerable thickness, which caps many of the higher ranges in Agamé, and the steep white scarps of which are perhaps the most striking natural feature in northern Tigré. It is in places about 1000 feet in thickness, but usually less. No fossils have been found in it, and its age is uncertain. Messrs. Ferret and Galinier class it, though with doubt, as Tertiary; but as I found it to all appearance distinctly passing beneath the oolitic limestone of Dongolo south of Adigrat, it is evidently of older date. It is far from clear whether the limestone rests conformably upon it; probably it does not do so, as otherwise it is difficult to understand the total absence of the limestone about Adigrat and Senafé, where trap alone rests on the sandstone. It is possible that the coal-bearing sandstones known to exist west of Lake Dembea may belong to the same series as the Adigrat sandstone.

The Adigrat sandstone always rests on metamorphic rocks. It is succeeded by limestone, as already mentioned at Dongolo; but near Adigrat it underlies trap, probably of the Mágdala group, with apparent conformity.

Antalo limestone.—The next group in ascending order consists chiefly of limestone; and in this, for the first time, fossils occur in some abundance. The rock is pale-coloured and usually well stratified; it occupies the line of route taken by the British force for about 70 miles from Dongolo till south of Antalo. To the north scarcely any other beds are interstratified; but further south, especially near Antalo, both sandstones and traps are met with, the latter being always doleritic, and a portion of the bands being, to all appearance, contemporaneous. The uppermost part of the formation is of sandstone and conglomerate, which are best seen in the Mishek valley south of Antalo.

These limestones have been very well described by Messrs. Ferret and Galinier, who quite rightly attributed them to the Jurassic formation. Although fossils abound, it is singularly rare to find any in sufficiently good preservation for accurate determination; but amongst those obtained are the following:—

Hemicidaris, sp. nov., near *H. Luciensis*, D'Orb., and *H. Wrightii*, Cotteau.
Trigonia costata, var. pulla, *Sow.*
Modiola Baini, *Sharpe*, or a closely allied species.
Ceromya concentrica, *Sow.*
C. similis, *Sow.*
C., sp., perhaps a var. of *C. excentrica*, Sow.
Pholadomya sp., near *Ph. recurva*, Ag., and *P. concatenata*, Ag.
Ph., sp. near *Ph.* (*Panopæa*) *punctifera*, Buv.
Alaria, sp.
Cerithium, sp.

and numerous casts of bivalves.

Other forms occur; but the above are the most characteristic.

Trappean series.—Nearly all southern Abyssinia, with Shoa, is known to consist of bedded traps; and although they do not occupy so extensive a surface in Tigré, they nevertheless cover a very considerable tract.

On the road to Mágdala volcanic rocks were met with at Senafé, where several hills consist of basalt and trachyte. The latter passes into a claystone which simulates sedimentary rocks to a remarkable extent, and forms the singular bosses known as Senafé rocks, which were mistaken for sandstone by almost all observers; indeed I was myself deceived at first. Near Adigrat is a great range formed of horizontal beds of basalt, and probably, in the upper portion, which I had no opportunity of visiting, of trachyte; but it was south of Antalo that the great trappean area was entered, and traversed by the route of the army, without a break, to Mágdala.

This trappean series plainly consists of two groups, the upper of which was clearly seen resting unconformably on the lower in the valleys of Atala and Ayba south of Antalo. The lower division I propose to call the Ashángi group, from its great development around the little lake of that name; the higher the Mágdala group.

Ashángi group of traps.—The lower subdivision consists entirely of doleritic rocks.

Amygdaloidal basalts prevail, associated with volcanic ash or breccia. The beds are usually disturbed, and frequently inclined at considerable angles.

The only place where the traps of this group were seen resting on the lower rocks was in the Mishek valley, where they are based upon the upper sandstones and conglomerates of the Antalo limestone. The section is obscure; but there appears to be unconformity.

In mineral character there is a marked resemblance between the rocks of this group and those of the great trappean formation of Western India.

Mágdala group of traps.—These consist partly of doleritic, partly of trachytic flows and ash breccias, the former predominating in general, but the latter very largely developed, especially in the higher portions of the group, and frequently occurring in beds of great thickness, weathering into immense vertical scarps, to which the peculiar profile of the higher peaks is largely due. To these thick beds the Abyssinian chieftains are indebted generally for the almost impregnable hill forts which form so remarkable a feature of the country. A great proportion of the beds are brecciated; and many, both brecciated and non-brecciated, are highly columnar. Some sedimentary rocks were found interstratified in the gorge of the Jidda river and near Mágdala, but no fossils were detected in them.

These beds in Waag and Lasta differ from the subjacent group in being almost perfectly horizontal. To them I am disposed to refer the horizontal beds of the Harat range, west of Adigrat; and probably the lofty ridges of Simen (or Samen), west of the Takkazzye, are, in part at least, of the same age. If this be the case, this group of beds must once have covered the greater portion, if not the whole of Northern Abyssinia, and have been removed by denudation, which in all probability was entirely subaërial. Their detritus, spread over the valley of the Nile, doubtless accounts in a great measure for the fertility of Egypt.

It is difficult to say whether the singular trachytes of Senafé, which are probably identical in origin with the well-known peculiarly formed ranges around Adowa, belong to the same group. They may be accumulations around the ancient volcanic nuclei.

Nothing positive can be asserted as to the exact geological age of either group of traps. The great outbursts which have covered Western India are Upper Cretaceous* (prenummulitic); and the volcanic rocks so largely developed on the south coast of Arabia † are very possibly, in part at least, of the same age. There may be a general connexion between all these enormously developed series of lava-flows, without their being absolutely contemporaneous. Their enormous mass and their persistent horizontality, in many instances over large areas, entitle them to greater attention than they have over received.

* See Memoirs of the Geological Survey of India, vol. vi., Art. 3.

† Carter, Journal Bombay Br. Roy. As. Soc. vol. iv. pp. 28, 91, &c.

Aden series of volcanic rocks.—Along both shores of the southern portion of the Red Sea and of the Gulf of Aden, there is an immense development of volcanic rocks, amongst which are many recent and, it is said, a few active craters. These formations have been described by several travellers*.

Near Zúlla, on the west side of Annesley Bay, these beds are but sparingly represented; but all the eastern shore of the inlet consists of them. Near Massowa they are better seen and consist of lava-flows interstratified with beds of ashes and of sedimentary deposits, gravels, and sandstones, some of which contain marine shells.

The lava-flows differ entirely from all the volcanic rocks of the highlands, and are assuredly of much later date. Still some of them may be far from recent, the great denudation they have undergone in places indicating considerable antiquity. As a rule they are inclined and present the appearance of having been much disturbed.

Recent formations.—These are not, for the most part, sufficiently important to demand much attention. Large alluvial deposits exist along the coast, north of Massowa and elsewhere, which appear not to be marine, but are more probably due to the washing down of pebbles and sand by rain and small torrents from the hills. They are frequently of considerable thickness.

Black soil precisely similar to the "regur" of India exists in the neighbourhood of the basaltic rocks on the highlands, and is probably derived from their decomposition. Of the plateau (Wadela-Talanta) between the Takkazzye and Jidda rivers, the northern half, where traversed by the British force, was of trachyte and had no black soil on it; the south consisted of basalt covered by black soil. The latter, just like the Indian "regur," seemed peculiarly well adapted to the growth of cereals †.

Denudation.—The enormous gorges cut by the rivers near Mágdala attracted general attention, though they are in reality trifling when compared with those of the Takkazzye and other rivers. If it is correct to believe that the trappean formations once covered Abyssinia (and certainly it is difficult to escape the conclusion), then from 4000 to 10,000 feet must have been removed from by far the greater portion of the surface. There is not a trace of marine denudation over the surface examined.

Lake Ashángi.—This small piece of water, the only one of the Abyssinian lakes which it was possible to visit, lies in a small basin of basaltic rocks and has no visible outlet. The perfect sweetness of the waters, and the absence of any evidence of great change of level, prove that a subterranean outlet must exist. It is by no means clear how the rock-basin has been formed. Its form is opposed to the idea of its having been due to glacial action, and no trace of the former existence of glaciers could be detected; but it

* Ferret et Galinier, 'Rocher d'Hericourt,' &c.

† It should be remembered that some Indian black soil can scarcely be derived from basalt. Such is the case in the extensive deposits of the lower Cauvery valley. Those who have only seen the soils of western India are sometimes not aware of this.

should be remembered that the surfaces of basaltic rocks are very susceptible of decay.

DISCUSSION.

Mr. ETHERIDGE remarked on the similarity of the Oolitic specimens to those from the Cotteswold Hills, and also to those from the Holy Land. Similar fossils also occurred in the far east, and even in Australia.

The PRESIDENT remarked that this range was not greater than that of some recent species; and in answer to his inquiry,

Mr. BLANFORD stated that there were no marks of glaciation discernible in Abyssinia, the excavation of the valleys being apparently due to the excessive rainfull.

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5. *On the* GRAPHITE *of the* LAURENTIAN *of* CANADA. By Prof. J. W. DAWSON, LL.D., F.R.S., F.G.S.

(The publication of this paper is postponed.)

[Abstract.]

THE author described the modes of occurrence of great quantities of graphite in the Laurentian limestones of Canada. It occurs both in beds and veins, the latter generally not true fissures, but shrinkage-cracks or segregation-veins. It is also disseminated, in scales &c., through the substance of the rocks. The graphitiferous rocks are widely spread, both in Canada and the neighbouring portion of the United States. The author discusses the origin of this graphite, which he ascribes to the conversion of the remains of plants into bituminous matter, from which the graphite has in its turn been derived. In some cases he has found traces of fibres which he thought might be the remains of terrestrial plants. In conclusion the author referred to the interest attaching to this matter in connexion with the study of the conditions prevailing at the time of the deposition of these limestones, and especially as furnishing evidence of an abundance of vegetable life in the "Eozoic" period.

DISCUSSION.

Prof. BRAYLEY inquired whether there was any proof that the substance called graphite might not be anthracite. He did not himself know of any instance of the passage of one of those substances into the other, and regarded graphite as of chemical origin, and not as directly derived from vegetable matter.

Mr. MALLET did not think that it was possible for any organic forms to remain in a substance so purely crystalline as typical graphite. The presence of organic remains was an argument in favour of the masses mentioned in the paper being lustrous anthracite rather than graphite.

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6. *On the* Correlation, Nature, *and* Origin *of the* Drifts *of* North-west Lancashire *and a* part *of* Cumberland, *with* Remarks *on* Denudation. By D. Mackintosh, Esq., F.G.S.

Contents.

1. Introduction.

Are the drifts of different districts merely local variations of one great formation which cannot be systematically divided? or can these deposits in their more persistent features be satisfactorily synchronized over extensive areas? As this is a very important question, and as little or no notice of any attempt to classify or correlate the drifts of the north-west of England has yet been communicated to this Society, the author hopes that the following account of observations made during prolonged visits to Blackpool, Ulverstone, and Lancaster in 1868–69 may not prove unacceptable.

2. Coast-Section of Drifts at Blackpool.

There are perhaps few parts of England where such extensive and instructive sections of distinct kinds of drift are clearly exposed as in the immediate neighbourhood of Blackpool. Beyond an acquaintance with the fact, derived from the Geological Magazine *, that Mr. Binney, F.R.S., had found sea-shells in, and had written on these drifts about eighteen years ago †, when the triplex division of drift

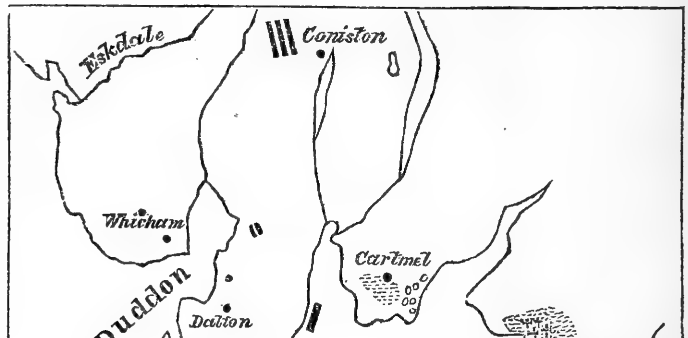
* Mr. Darbishire on "Drift-beds," vol. ii. No. 7, July 1865.
† Memoirs of the Lit. and Phil. Soc. of Manchester, vol. x.

deposits had scarcely been suggested*, the author thought it best to remain ignorant of what had been said about this particular locality previously to his making a series of personal observations†.

* Mr. Hull has lately worked out this division in some of the more inland districts of Lancashire. See Mem. Lit. Phil. Soc. Manchester for 1863–64, and Memoirs of the Geological Survey.

† Since making observations on the Blackpool drifts, I have seen perhaps the finest section of the three drifts in vertical succession to be met with in south Britain. It is about 150 feet high, and embraces Lower Boulder-clay, middle sand and gravel, and Upper Boulder-clay. The drifts are exposed in a river-cliff at Redscar, about three miles north-east of Preston. They will be described in one of Mr. Hull's forthcoming Geological Survey Memoirs. The Lower Boulder-clay is here much less stony than at Blackpool and in Furness.

Fig. 1.—*Sketch-map of parts of Lancashire and Cumberland.*



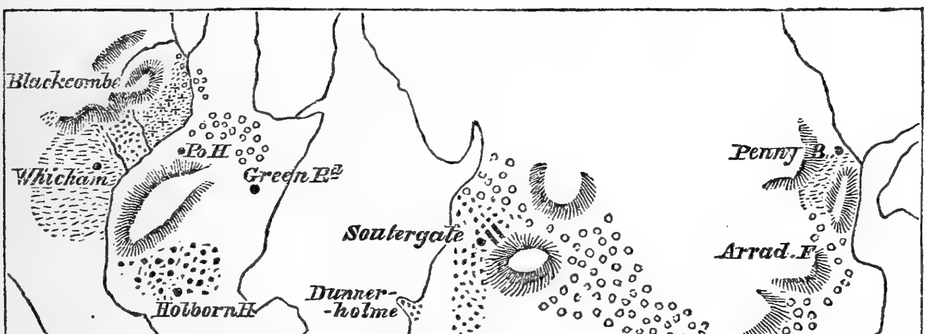
Lower Boulder-clay. Middle Sand and Gravel. Upper Boulder-clay.

EXPLANATION

The Maps of north-west Lancashire and part of Cumberland are intended to give
are either driftless, or they have not been examined by the author. In Furness
believed to be equivalent to the more decided drift of the neighbourhood.

a. Upper Boulder-clay.—The existence of an Upper Boulder-clay along the coast is clearly defined. It stretches into the interior to an unknown distance. On the coast it thins out and disappears in a southerly direction. A considerable thickness of it may be seen as far south as Market Street, Blackpool, in a recess on the west side of which this clay is now in course of being excavated (Dec. 1868). It may be seen in the railway-cutting near the Blackpool station, further south in the brick-pits near the National School; and I have traced it thinning out over a light-coloured tenacious clay (Lower Boulder-clay ?) east of the old Independent chapel (see Postglacial deposits). West of the Independent chapel, the clay now in course of being carted away to the south shore appears to be a deeper,

Fig. 2.—*Sketch-map of the Peninsula of Furness.*



Boulder-clay of uncertain age, with sand and gravel.

Glacial striæ.

OF THE MAPS.

a rough idea of the distribution of drifts. Where there is no stippling, the areas the stippling in some places is extended to areas covered with earth and detritus No attempt has been made to map the Postglacial deposits.

tougher, and more marly part of the Upper Boulder-clay. The stone facing or "hulking" of the sloping shore from the New Pier to the Gynn, conceals this clay on the coast; but in the gully close to the Gynn Inn a fine coast-section of it commences. It reaches a thickness of at least 30 feet, and may be distinctly seen overlying the middle sand and gravel for a distance of about two miles in a northerly direction, and irregularly attenuating until it is lost under blown sand. In its upper part it is generally of a dull red colour and somewhat incoherent; in its lower part it is compact, and often of a grey or blue colour. Generally speaking, though not always, stones are rather sparingly distributed through it, and they are seldom large. A kind of grey siliceous sandstone, occasionally with quartz veins, is perhaps the most prevalent; but greenish grey porphyry is very common, and granite not unfrequent. A large boulder may here and there be seen. The upper part of this deposit is used as a brick-clay and the lower as a marl*. It is apparently devoid of stratification, though, I believe, the action of spades in brick-pits and of rain on sea-cliffs is capable of effacing all traces of bedding in either of the Boulder-clays (see Lower Boulder-clay between Bardsea and Baycliff). The Rev. Mr. Thornber informed me that he found a lump of hæmatitic iron-ore from the Furness district in this clay.

b. Middle Sand and Gravel.—Beneath the Upper Boulder-clay a very fine section of sand and gravel may be seen exposed in the cliff north of Blackpool. It would appear to thin out in a southerly direction before reaching Blackpool, or under some part of the town, as no trace of it can be detected on the coast south of the New Pier, where the lower clay comes nearly to the surface, and is directly overlain by Scotch *slutch* or (a little further inland) by the upper clay. I have not seen it exposed further south than the Gynn gully. It cannot be cut off by a fault in the gully, as the lower clay underneath preserves a nearly uniform level all along the shore. It probably wedges out between the two clays a short distance to the south of the Gynn. In the Gynn gully, about 30 feet in thickness of the sand may be seen capped with the upper clay. Here the edges of the laminæ have to a certain depth been cut off by denudation on the landward side. To the north of the Gynn the deposit of sand and gravel is well known; and many sea-shells (*Cardium*, *Tellina*, &c.) have been found in it by Mr. Binney, Mr. Darbishire, and others. It consists of successive beds of fine and coarse sand displaying many varieties of oblique lamination and false bedding, alternating with layers of well-rounded pebbles likewise more or less false-bedded. The sand comes nearly to the surface immediately to the north of Uncle Tom's Cabin, but again becomes covered with the upper clay. Northwards, nearly a mile beyond Uncle Tom's Cabin, the middle drift consists almost entirely of arenaceous beds (capped with clay) which dip towards the north at a small angle, the surface of the ground above nearly conforming to the dip, until in the direction of Rossall these beds are lost under blown sand.

* The existence of marl-pits in this part of the country may almost be regarded as an indication of Upper Boulder-clay.

c. Eagberg "Rockery."—In the Eagberg cliffs, north of Uncle Tom's Cabin, both the laminated sand and pebble-beds have here and there become consolidated into rock as hard as some kinds of millstone-grit *. Owing to the formation of rain-ruts on each side and the washing away of the looser matter underneath, fragments of the sandstone or conglomerate become undermined and fall down. In their descent they either reach the beach or become entangled in the facing or talus of fallen clay. In the latter case they project from a temporary matrix of soft or loose matter, in which they are believed by the country people to have grown. The harder laminæ of sand and layers of pebbles project beyond the softer parts, giving rise to fantastic shapes. In their merely fallen state they are, I believe, of comparatively little value; but when they are reached by spring tides, and smoothly rounded by the waves, they are highly prized as ornaments to enclosures in front of houses &c. They sometimes resemble certain styles of architecture, the gothic arch and window included, and often mimic the table and smith's anvil. They are believed to become harder by exposure to the sun. About half a mile (some say a greater distance) from the present cliff-line a very large split block, called Pennystone, may be seen, at the lowest-water mark. It is a mass of consolidated middle drift, much too large, it is believed, for the sea to displace. It is supposed to lie in the spot where it fell from the then-existing sea-cliff, and is looked upon as an evidence of the removal of half a mile of Eagberg hill by the gradually encroaching sea since the days of Edward II. Near it there is a smaller stone called the Carlin or Witch-stone; and both stones are referred to in the following traditional couplet:—

> Penny stood, Carlin fled,
> Red bank ran away †.

Except during exceptionally high tides, the sea does not now encroach on the "Red bank."

d. Lower Boulder-clay and Loam.—I have traced this formation under high-water level from a point nearly half a mile south of the New Pier to more than half a mile beyond Uncle Tom's Cabin. In most places it is temporarily, in some places perhaps permanently covered with recent sand and shingle; but it exhibits larger or smaller areas which at any time may be seen swept clean of all loose materials. Near the coast, where its surface slopes a little seaward, it resembles a hard artificial concrete pavement. Further out at sea, and at a lower level, its character is varied. The following notes

* It is interesting in connexion with this fact to notice that Mr. G. Maw has observed hard blocks of consolidated sand and gravel occurring at a certain level though not in a connected band, in the drift intervening between the chalk and (Upper) Boulder-clay of the high ground of Suffolk (Quart. Journ. Geol. Soc. Jan. 23, 1867). This consolidated sand and gravel is probably of the same age with that at Blackpool.

† For this information I am indebted to the Rev. Mr. Thornber, of Blackpool, a well-informed antiquarian. Red bank signifies the drift-cliff reddened by the facing of Upper Boulder-clay, which is continually falling down and obscuring both the middle sand and gravel and Lower Boulder-clay.

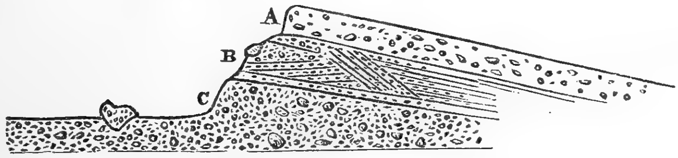
refer to different portions of it near mid-tide level, or to the same portions modified by fresh sections being exposed at different times by the sea:—South of New Pier the Lower Boulder formation cannot be easily described. Within a small compass it seems to vary both in vertical and horizontal succession—in one place a fine, uniform, tough, and bright yellowish-brown clay more or less laminated, in another a fine loamy sand—here a rather solid brown clay with a grey marly or shaly fracture, there a coarse sand charged with stones. But you cannot travel far without seeing these variations of structure graduating into, or succeeded by, the main character of the formation, namely a very hard brown clay generally full of subangular and rounded stones, varying from the smallest size up to boulders commonly so called. They consist of porphyry, granite, &c., the proportion of igneous and metamorphic rocks being greater than in the upper clay. The loose pebbles on the beach would here appear to have come chiefly out of this formation; and to it may be traced nearly all the large boulders which occur at intervals. Some of these boulders reach the size of 5 feet in diameter. Many of them continue firmly fixed in the clay, where they have probably remained since they were first imbedded. The sea washes the clay from around them, and by the gyratory action of its waves excavates circular depressions; and in this way it has probably succeeded in uprooting and displacing some of the boulders* North of Blackpool Old Pier, a fine clay, loam, and hard stony clay similar to the above make their appearance under mean-water level. A short distance to the south of the Gynn, in the bed of the sea, the fine bright yellowish-brown loam exhibits oblique and curved lamination, the thin layers cropping out around small synclinal basins. Further north, near Uncle Tom's Cabin, the finer part of the Lower Boulder formation assumes the form of a laminated reddish brown sandy loam nearly as solid as rock. Beyond Uncle Tom's Cabin a similar deposit may here and there be seen at low water; but there, as on the south beach, it graduates into the prevailing hard stony clay. Along the whole shore, nearer to the cliff-line, the hard stony clay may be traced. It is probably a higher bed than the one containing fine clay and loam; and a great part of it would appear to have been recently denuded. Of its former thickness, at least in some places, one may form an idea from coast-sections north of Uncle Tom's Cabin. Under the middle sand and gravel, and separated from this formation by a distinct line of demarcation, the hard stony clay rises in two places above the base of the cliff, as represented in figs. 3 and 4. In the most northerly instance the lower part of the cliff, to the height of at least 20 feet, is composed of it. It likewise forms the solid floor of the beach for some distance seaward†. This is a favourable

* During the very high tides of January and February 1869, according to newspaper reports, several large boulders were displaced, and one of them thrown up on the promenade.

† Northwards it disappears under the dipping sand-beds of the middle drift. In the cliffs further south a removal of the talus might reveal sections in addition to those I observed.

spot for studying the prevailing character of the hard stony clay (Lower Boulder-clay). In the lower part especially, it looks like a kneaded mass of clay, grit, and stones of various sizes. Grains and small fragments, as well as good-sized stones of quartz, here enter considerably into its composition, and give it a speckled appearance. Many of the stones are igneous or metamorphic: some are well rounded; but generally speaking they appear little more than blunted or rubbed, as if they had been pushed along. Most of them are more or less scratched and striated.

Fig. 3.—*Transverse Coast-section of Drift to the north of Uncle Tom's Cabin.* (Cliff about 70 feet in height.)



A. Upper Boulder-clay. B. Middle sand, gravel, and "rockery." C. Lower Boulder-clay.

e. Postglacial Deposits.—On the coast south of Foxhall Inn, and extending far in a southerly direction, a Postglacial clay may be traced. Near its northern termination, and some distance out at sea, I found a thin remnant of it resting on the Lower Boulder-clay. It is well exposed on the shore near the promenade now in course of being constructed (December 1868)*. It may be about 15 feet in thickness. It is of a very soft and yielding character, and here and there exhibits curved lamination. It is more or less charged with decayed vegetation, and in many places is full of very small stones, generally smaller than a pea. The lower part, called Scotch *slutch*, is of a light bluish-grey colour; the uppermost foot, called *white ore* or *stepmother's jag*, of a very light grey hue. It includes at least one thin layer of peaty matter. On the coast it is overlain by a bed of peat between 2 and 3 feet thick. Inland it varies in thickness, and here and there thins out, as if it had been accumulated in hollows, and it is generally overlain by peat, which in many places is covered with stratified sand†. The latter would appear to have been deposited when the land was slightly lower relatively to the sea than at present, though it ought not to be forgotten that this area is still subject to high-tide inundations. A part of the low ground behind Southshore was formerly occupied by Marton Mere‡, in the bed of which, the Rev. Mr. Thornber informed me, the skin of a British canoe (the wickerwork decayed) was found many years ago §.

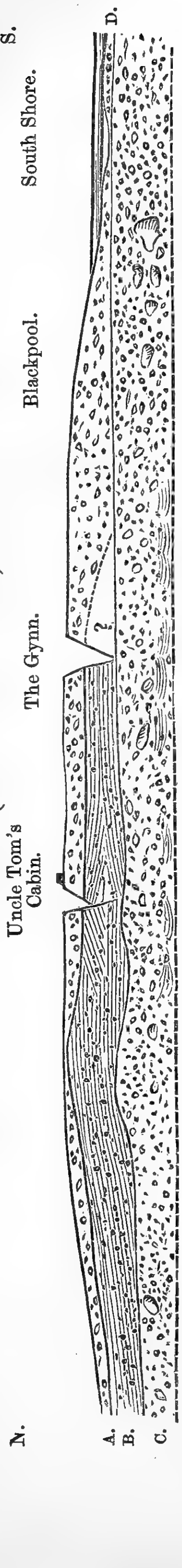
* It is possible that some of the coast-sections described in this paper may have been destroyed or confusedly mixed up with artificial accumulations by the tides of January and February 1869.

† The stratified sand is replaced by or covered with blown sand between South Shore and Lytham.

‡ The site of a mere near Southport is called Marten.

§ We may soon expect from Mr. De Rance (of the Geological Survey) the *f. Origin of the Blackpool Drifts.*—Leaving the question of the origin of the Postglacial deposits to those who have devoted more attention to their character as exhibited on different parts of the Lancashire coast, I may remark that while few would doubt the marine-glacial origin of the Upper Boulder-clay, and while no one can dispute the purely marine origin (with the exception of boulders drifted into it by floating ice) of the middle sand and gravel formation, the precise mode of accumulation of the Lower Boulder-clay appears involved in mystery. At first sight any one might hastily conclude that it is a land-glacial deposit; but a reconsideration of its varied phenomena, and a correlation of this clay with what we have reason to believe are equivalent deposits on the other side of Morecambe Bay (see sequel) and in South Lancashire, would seem to point to accumulation under mixed glacial and marine conditions. Admitting that the stones and a great part of the clay were furnished by land-ice (in the Carnforth area the stones would appear to have been transported chiefly by coast-ice; see sequel), the sea at least must have kept up what may be called a running accompaniment to the accumulation of the drift-matter, by washing out and redepositing its finer parts in the shape of laminated loam. In some parts of North-west Lancashire the Lower Boulder-clay may be entirely a land accumulation; but it is difficult to resist the belief that where this formation spreads out continuously over large flat areas, it must have been deposited under the surface of the sea*. It may likewise be remarked that at Blackpool the numerous granitic boulders and stones, which could not

Fig. 4.—*Longitudinal Coast-section of Drift from near the French College to about a mile beyond Uncle Tom's Cabin* (not drawn to scale).



A. Upper Boulder-clay. B. Middle sand, gravel, and "rockery." C. Lower Boulder-clay and laminated loam. D. Bluish grey clay or warp, called Scotch slutch and white ore, overlain by several feet of peat, the latter covered with bedded sand.

results of the first thorough, minute, and systematic investigation that has yet been made of the succession of Postglacial deposits and their connexion with deposits of the prehistoric and historic periods. He has been surveying the country south and east of Southport.

* I have just learned (March 1869) that Mr. Morton, F.G.S., some time ago discovered sea shells in Lower Boulder-clay near Liverpool, and that one of the Geological Surveyors (whose name I am not yet at liberty to publish) has made a discovery during a short visit to Blackpool which demonstrates that the Lower Boulder-clay there, is, at least partly, of marine origin.

have come from a less distance than Eskdale, would seem to favour the idea of floating ice; for while it is generally admitted that the bulk of land-glacial drift must be local, it is very improbable that a flow of land-ice from Eskdale, on reaching what is now the bed of the Irish Sea, should have turned round in the direction of Blackpool; and this improbability will still further appear when we take into consideration the fact that the primary striation of North-west Lancashire is from north to south, or from north-north-east to south-south-west (see sequel).

3. Drifts between Lancaster and Carnforth.

Between Blackpool, Preston, and Lancaster the country is more or less covered with drift, which I had little opportunity of examining; and between the valley of the Lune and Carnforth my opportunities of observation were more limited than in the three other districts noticed in this paper. On walking from Lancaster to Carnforth one cannot fail to be struck with the enormous mass of drift which almost everywhere conceals the solid crust of the earth. Its thickness in many places cannot be less than 200 or perhaps 300 feet. Its surface is very undulating, in some places consisting of knolls like a flattened form of *esker*, in others presenting the appearance of parallel *drumlins* *, though on minute inspection it is seen that the latter are not sufficiently parallel or regular to be correlated with the drumlins of Ireland. I was unable to see any exposure of drift in which the line of contact between two distinct deposits could be clearly made out. At Hest Bank I fancied that the sea-cliff showed an indistinct line of demarcation between a hard Lower and a comparatively yielding Upper Boulder-clay, but could not make sure of the existence of more than one formation, and that apparently Lower Boulder-clay.

The two fine sections at Hest Bank consist of sea-cliffs cutting across drift-knolls. The one furthest from the railway station is about 50 feet in height. The clay is full of stones, of sizes varying from small pebbles up to very large boulders of limestone. They are much striated, and often rounded only on one side. Between here and Morecambe, and along the beach at Morecambe, large stones are generally found in groups, which might merely indicate the places where the Boulder-clay came to the surface, were it not that where this formation runs *continuously* for great distances along the coast the large boulders occur, with few exceptions, in groups—a circumstance which, if well established, would indicate their having been dropped by floating ice rather than left by land-ice †.

On the hill near Lancaster, called Lancaster Moor, a hard reddish sandy clay, very much resembling lower Boulder-clay in its structure, may be seen resting on a surface of millstone grit which has been glaciated either towards or from the valley of the Lune, in my

* The Rev. M. H. Close (see Journ. Roy. Geol. Soc. Ireland, vol. i. part 3) believes that the parallel ridges called *drumlins* were accumulated under land-ice.

† In Staffordshire, Shropshire, &c. the boulders of granite, porphyry, and other far-transported rocks are generally found in groups.

opinion glaciated up hill either by a great flow of land-ice or by floating ice. The mode of striation of the stones which have been taken off the fields, or dug out of one or both Boulder-clays, and heaped on the road-side between Lancaster and Carnforth, would seem to point to the action of floating ice. The striations very frequently occur on more than one side, often on nearly opposite sides, and sometimes all round the stone, in a manner indicating that the stone was not only turned over during the process, but twisted round horizontally.

Beyond Carnforth railway-station a section of reddish Boulder-clay full of stones lying at all angles has been exposed in a cutting. South of the station the cutting reveals the most extensive section of sand and gravel I have yet seen. It reaches a thickness of nearly 100 feet, and is about a quarter of a mile in length. It is so extremely varied as almost to defy description. For a considerable distance there are few or no large stones, the deposit consisting of alternating beds of coarse and fine sand and coarse and fine gravel, obliquely laminated and false-bedded on an extensive scale. There are several interpolated beds or masses of unstratified gravel, and towards the bottom a thick bed of laminated loam. The stones are not striated, with the exception of a very few of the largest, which are scratched all round. Some of the layers of sand and pebbles are as hard as Eagberg rockery. Further south the gravel contains a number of very large stones striated in various directions; it then becomes one mass of stones lying at all angles, and as firmly compacted as the stones of the Lower Boulder-clay; it afterwards graduates into a regularly stratified and false-bedded gravel, which further on contains a great number of large boulders. The beds of the Carnforth section are apparently contorted to a certain extent, but not nearly so much so as in the sections near Ulverstone. The stones are nearly all limestone.

a. Derivation of Limestone Boulders.—Supposing the smaller stones which compose the false-bedded part of the gravel to have been amassed by currents, the large boulders could not have been moved to their present positions independently of ice-action. But a study of the physical geography of the district will convince one that when the land was submerged to the depth indicated by the sand and gravel, the upper parts only of the neighbouring limestone hills or peninsulas could have remained above water. Under such conditions land-ice could not have furnished the great bulk of the boulders included in the Carnforth gravels; and the rounded form of these boulders would seem to point to their having been subjected to sea-coast action previously to their transportation. We are thus led to regard coast-ice as the agency by which they were moved; and we need not travel far to find forms of ground and situations from which the boulders may readily have been launched. The face of Warton Hill, nearly opposite Carnforth, presents a series of platforms and cliffs with scattered blocks and fragments; but it was while walking from Warton to Yealand that I was the most impressed with what appeared to be old sea-beaches covered with more or less rounded limestone blocks, and bounded by cliffs. I had not time to ascertain if the protected sides of these blocks were striated; but they looked as if they had only accidentally escaped being transported by the floating ice, which, for all that we can tell, may have carried away many of their fellow boulders and dropped them into the slowly accumulating gravels and clays of the then adjacent sea-bottom.

4. Denudation of Drift Deposits.

The drift-areas of N.W. Lancashire present a succession of smoothly-rounded heights and hollows—the vertical extent of the undulations reaching 200 feet. Sections show that this varied surface is mainly the result of denudation, and that the denudation has proceeded irrespectively of the structure of the underlying deposits. The lower and upper part of a knoll may consist of distinct kinds of drift; one side of a knoll may be made up of one kind of drift, and the opposite side of another kind; and all the phenomena would seem to point to a denudation of a broader and more sweeping nature than any form of atmospheric action.

a. Origin of Lake- and Swamp-basins in Drift.—Perhaps the most prevalent form of hollow presented by the surface of drift-deposits (at least in some districts) is the shallow *basin*. It is merely a continuation of the general undulating surface; and there is no reason for supposing that its *lowest* side has been left by deposition. The basin becomes a swamp, marsh, mere, or temporary (sometimes permanent) lake. In many places these wet depressions remain; in most places they have been artificially drained. Scores of them may be seen between Blackpool and Carnforth, and not a few in the Furness peninsula. Were these basins scooped out by land-ice? The fact of their often occurring on the surface of *Upper* Boulder-clay shows that they could not have been subjected to land-glacial action (they generally occupy positions remote from upland valleys, in which glaciers may have lingered till after the glacial submergence), unless we agree with the Rev. O. Fisher in believing in a supplementary glacial period occurring between 100,000 and 200,000 years ago, during which a great sheet of land-ice gave the latest finish to the configuration of the ground. It might be out of place in a paper of this kind to discuss the question of the excavation of these drift-basins beyond expressing an opinion that the idea of their formation by submarine currents can be better included than any other in a consistent scheme of the succession of glacial and post-glacial events.

b. Subaërial Denudation of Drift Deposits.—Where the surface of the drift does not exhibit a succession of knolls and basin-shaped depressions, it spreads out in the shape of uniformly flat plains, as between Preston and Longridge, and other parts of South Lancashire. Shallow ◡-shaped passes, at greater or less intervals, cross these plains often nearly at right angles, and without any connexion with the direction of the drainage*. Freshwater streams have taken advantage of

* Between the estuaries of the Mersey and the Dee two depressions, evidently once tidal channels, run across from sea to sea.

the depressions; and the sharply defined brinks of the gullies they have excavated can at once be distinguished from the neighbouring form of ground. But streams in many places have made channels where little or no previous depression existed. The steepness of their sides varies with the compactness of the drift, the absence of springs, &c. But though the streams have been flowing in their channels ever since the Glacial period, rain has not been able to bevel down the sides of these channels to a lower average angle than 30°. Geologists ought therefore to hesitate before attributing to rain the excavation, *in hard rocks*, of valleys the sides of which rise above the river-channels at an angle of only 4° or 5°.

c. Origin of Drift Escarpments and Valley-plains.—As already remarked, depressions must have been formed in drift deposits before their elevation above the sea*. As waves at a stationary level are now wearing the slopes of these depressions back into cliffs, it is reasonable to suppose that the cliff-lines now bounding valley-plains which have partly or wholly risen above high-tide level have been formed by wave-action. Rivers have wandered over these plains, and during floods deposited sand or loam. In many places they have attacked the cliff-lines and worn them back into horseshoe-shaped curves. But some of the concavities in the drift escarpments bounding low-level valley-plains have escaped river-action, as would appear from the direction of the dip of the ground under them, from their form relatively to the old gullies which abruptly break their continuity, from transverse sections of the bases of the escarpments revealing the kind of agency to which they were last subjected, &c.

The river Ribble, at Redscar Cliff, near Preston, has evidently only lately attacked the concave escarpment, a part of which it is undermining and carrying away, while a great part of the cliff-line on both sides of the valley-plain traversed by this river shows indications of its having been formed by the sea†.

5. Smoothed Rock-surfaces and Drifts of the Furness Peninsula.

Between Carnforth and Ulverstone, along the sea-coast, several sections of drift may be seen exposed. To the west of Grange the hard Lower Boulder-clay appears in full force, and looks either like an old beach under an escarpment, or a fringe of a formerly extensive deposit. At Cark Station gravel and sand make their appearance. In the neighbourhood of Ulverstone one cannot proceed very far in observing drift-sections without seeing the importance of beginning his researches with examining the forms presented by the rock-surfaces of the district.

a. Distinction between Glaciated, Rain-worn, and Sea-worn Rock-surfaces.—Ice, especially land-ice, is a *planing* agent. It uniformly

* In each successive drift deposit depressions must have been scooped out *while the deposit was under the sea*, as these depressions are filled up with overlying drift. The latest depressions formed in drift must have risen above the sea without being filled up excepting by postglacial warp, &c.

† Mr. De Rance, of the Geological Survey, accompanied me when I examined the drift escarpments near Preston, and agreed with the conclusions at which I arrived.

shaves away the edges and grinds down the faces of stratified rock-masses. It can produce an undulating surface; but the vertical extent of the heights and hollows must be small in comparison with their breadth. It cannot scoop out small deep basins, deep grooves pointing in various directions, and, least of all, funnel-shaped holes running down through slabs of rock. Water finding its way through cracks in glaciers may perhaps produce all these forms of rock-surface in valleys; but on the summits of limestone hills such phenomena must be referred to the action of rain or sea-waves. Rain (as I have already shown in this Journal*) cannot *grind* rock-surfaces so as to leave smooth curvilinear hollows cutting continuously through hard and soft parts of the stone; but it must communicate a rough irregular surface minutely corresponding to variations in lithological structure or composition.

b. Rock-work of Birkrigg Moor and Hampsfell.—On the rocky summit called Birkrigg Moor near Ulverstone, and on the still higher eminence called Hampsfell, near Grange, rain is now clearly breaking up everything like regularity of form. It is converting previously smooth basins into rough, pitted, and fretted depressions, and smooth grooves into jagged stone gutters. But these hills, especially the borders of Birkrigg Moor, present proofs of the most undeniable kind that no agent has formed the smooth and regular rockwork since the Glacial period. The basined, grooved, and funnelled surfaces of limestone rock run under drift without any change of form, excepting that, under damp clay, in many places the surface has been roughened. The connexion between sculptured limestone rock-surfaces and drifts in this district offers a new field of research to the geologist. So far as I have observed, the hollows must nearly all have been ground out before the deposition of the Upper Boulder-clay. They not only run under a loose reddish drift on the borders of Birkrigg Moor, but under the decided upper drift further westward; and sculptured boulders may be seen buried in this drift. Large sculptured boulders on Stainton Green (see sequel) present grooves and other hollows running continuously from the upper to the under surface, and along the latter down into the matrix of red loam†. The semi-island of Dunnerholme (see sequel) is covered with an upper drift which rests on sculptured limestone—*the rounded stones of this drift still sticking in the funnel-shaped holes they apparently helped to grind out.* But the period of the sculpturing of the limestone rocks must be carried still further back; for sculptured boulders may be found in hard Lower Boulder-clay, though in this clay the sculptured surface, the typical form of which can be at once recognized, has become irregularly pitted. Under the Lower Boulder-clay the rock-surfaces often present the same general forms, though in most places they have become fretted through some kind of chemical action, probably intensified by the humus carried down from the surface by rain-water percolating through crevices.

* Quart. Journ. Geol. Soc. vol. xxiv. pp. 277 & 278.

† On the sea-shore between Morecambe and Carnforth I have seen sculptured limestone boulders fixed in what looked like Lower Boulder-clay.

c. Glaciated Rock-surfaces near Ulverstone.—To the north of Ulverstone, between Arrad Foot and Penny Bridge, and near to a house called Gawith Field, I saw one of the finest specimens to be met with in this country of a broadly and regularly grooved surface. The flutings were on the whitened face of a block of dark grey porphyry which had been built into a wall. But the most extensively glaciated rock-surfaces in the Furness peninsula may be seen on the sea-coast between Bardsea and Baycliff. The Boulder-clay, locally called "pinel," has been stripped off the glaciated rocks by the sea. The striæ run approximately N. and S., or between N. and S. and N.N.E. and S.S.W.; but in many places the lines cross each other at small angles in a very confused manner, as if the icy handle of the graving tool had moved unsteadily. Some of the boulders may be seen with striations crossing each other at angles amounting to 15°. In many places under the pinel the limestone-rock is not glaciated. These facts ought to be mentioned, as they bear more or less on the question of the origin of the pinel. Near Baycliff an observer, if he has not been forewarned, may become painfully acquainted with the most perfect specimen of a polished rock-surface perhaps to be found in this country *. Over a number of square yards the compact limestone has received so high a degree of polish that no one can walk on it without running a great chance of falling.

d. Lower Boulder-clay or "Pinel" between Bardsea and Baycliff—Indications of stratification.—On the east coast of the Furness peninsula the sea has exposed a fine section of pinel which reaches the thickness of about 20 feet. It commences a short distance to the south of Bardsea, and extends with little interruption to the south of Baycliff. In some places it is little more than a confused mass of limestone-débris apparently torn up from the underlying strata; in other places the stones are subangular; generally speaking they are more or less rounded, and occasionally as much so as ordinary beach-gravel. The stones are chiefly limestone, the same as the rock below; but many of them have come from the Silurian slate-district to the north. Sometimes the limestone, sometimes the Silurian boulders are the most rounded or the most angular, as if rounding did not depend on the distance travelled. In a few places there is the appearance of a line of demarcation between the hard or lower and the rubbly or upper part of the deposit, as if the latter represented the Upper Boulder-clay. Generally speaking, there is a well-defined line of separation between the pinel and the underlying limestone-rock, which is here and there, not everywhere, glaciated, as before remarked. The main character of the pinel may be described as a mass of excessively hard yellowish-brown clay packed full of stones of various sizes, including numerous large boulders. In some places it would be more correct to call it a conglomerate or

* Miss E. Hodgson, a talented local authoress, drew attention to this or to some neighbouring specimen of glaciated rock in the last volume of 'The Geologist,' and gave a well-written account of the drifts around Ulverstone at a time when the relative age and character of the drift-deposits of Lancashire were little understood.

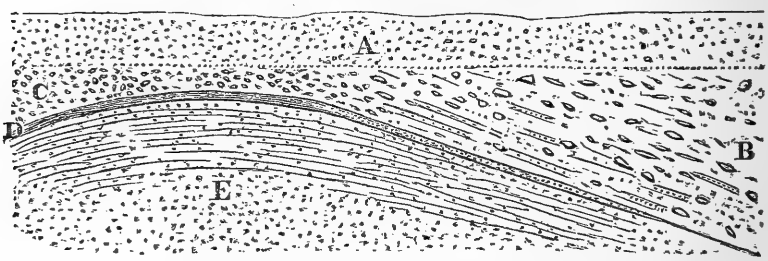
breccia than a drift. It is perhaps the most unworkable stuff in the world. The pick can make little, and the spade no impression on it; and it cannot be blasted. During my first visit to this section I could see no indications of stratification, and in my notes called the pinel a "terrible pell-mell accumulation;" but on examining it immediately after fresh faces of it had been exposed by the unusually high tides of the 31st of January, 1869, the appearance of stratification was very strongly marked. It was here and there curved, arched, and false-bedded, though the general dip was to the south at a small angle with the limestone floor underneath, a circumstance which is not easily explained on the theory of accumulation under either water or ice *. The lines separating the beds were as continuous as the number of imbedded stones would apparently allow; and in some places, where there happened to be few stones, the pinel was distinctly laminated. The pinel likewise presented the appearance of having been fractured at intervals; but whether the rents were continued into the underlying limestone I had not an opportunity of ascertaining. One feature of the pinel I think deserves particular attention. On the beach I saw a fallen boulder with hard laminæ of loam adhering to one side, and I afterwards found that some of the boulders in the pinel above were partly bedded in thin laminæ. As a mere attempt at an explanation of this phenomenon, I would suggest that the stone may have been held at a certain level by a mass of floating ice while the laminæ were deposited beneath it, or that after the first imbedding of the stone it may have been partly uprooted by ice floating from N. to S. so as to leave a space beneath it for the deposition of the laminæ. Mr. De Rance, of the Geological Survey, on seeing my sketch, expressed his belief that the mere tendency of sea-waves to insinuate themselves under stones firmly imbedded in drift might excavate a cavity on one side which might afterwards become filled with laminated loam, or clay. All these suggestions take for granted the presence of water, and are irreconcilable with the doctrine of accumulation under a great crust of land-ice. Here district or valley glacial action will not apply.

e. Pinel and Contorted Sand and Gravel near Ulverstone.—The difficulty of referring the accumulation of the pinel of this district to land-ice will still further appear when we come to observe the mode of its association with middle drift in the extensive section exposed west of the Ulverstone railway-station. I at first endeavoured to separate the pinel from the sand and gravel above it, but after five or six visits, between which fresh features were exposed, I could only arrive at the conclusion that the pinel is so dove-tailed into the lower part of the sand and gravel as to indicate that both formations must have been accumulated under water, and that ice must in some way have been instrumental in giving rise to the numerous displacements and contortions which render it almost impossible to unravel the details of this remarkable section. Instead of attempting to do

* I very lately observed an instance of similar stratification in the Lower Permian Sandstone at Pontefract.

so, I shall merely quote from my notes. At the east end of the section, and near to the railway-station I unexpectedly found real pinel in a deep side-cutting. Its surface was uneven, as if it had been denuded. In one place the sand and fine shingle had found their way through a narrow opening down into a cavity in the pinel. A little further west the pinel gives place to sand and gravel, as in fig. 5. Above the section represented in fig. 5 there is a great

Fig. 5. *Section near Ulverstone.*



A. Coarse gravel (lower part of middle drift). B. Pinel graduating into a bed of small pebbles with patches of sand, C. D. Yellowish-brown loam graduating into a thin pebble-bed eastwards. E. Bed of fine dark sand more or less laminated, depth unknown.

thickness of coarse and fine sand, coarse and fine gravel, and cleanly washed pebble-beds. Interstratification of coarse and fine materials, oblique lamination, and false-bedding are common. The beds are very much contorted, scarcely a layer being horizontal, many dipping at an angle of 45°, and some even at a higher angle. One boulder in the middle drift measured about $10 \times 4 \times 5$ feet. It was quite angular and not striated, in this respect differing from the more or less rounded and striated boulders of the pinel. At the west end of the railway cutting, where the ground falls, a bed of pinel about 3 feet thick rises nearly to the surface. It is covered with ochreous stony earth, and underlain by irregular layers of sand. Further east the pinel splits into two beds, one running up, another down, with a wedge of sand between. The upper bed graduates into a fine sandy loam with patches of pebbles; the under bed dips beneath the level of the railway and is lost. About the middle of the cutting there are several thick beds of sand and gravel. One of the latter, about 20 feet thick, consists of an unstratified mass of stones firmly compacted. It seems to differ from pinel only in the stones having a matrix of sand instead of clay, in their being more rounded, and in their not being striated. So far as the complicated phenomena presented by the Ulverstone railway-section furnish indications of origin, I think that while the middle drift was accumulated by almost purely marine agency *, the pinel implies nothing further than glacial-marine conditions.

f. Contorted Sand and Gravel in other parts of the Furness Peninsula.—Sand and gravel more or less contorted may be found running from

* Not quite, as the transported blocks and contorted stratification can only be explained by floating and stranding ice.

Ulverstone in terraces or knolls in the direction of Bardsea. A section of it, excessively contorted, may be seen in a pit at Gascow, near Conishead Priory. At Wadhead the sea has cut away about half of a sand and gravel knoll, containing unsteadily striated boulders and seams of consolidated sand. I have not had an opportunity of tracing the sand and gravel further south. West of Ulverstone it extends continuously for nearly two miles. It appears in the railway-cutting close to where the Dalton Road crosses the railway; and a section of it revealing false-bedding may be seen at the end of a row of cottages called Three Bridges. On the side of the road from Dalton to Ireleth, and in knolls to the S. and S.E. of Ireleth railway-station, and elsewhere in the neighbourhood, sections of it have been exposed. Between Ulverstone and the Duddon it reaches an altitude of at least 200 feet. Near the summit-level of a wide pass or saddle between Penny Bridge and Arrad Foot (north of Ulverstone) a number of pits have been dug in a gravel knoll. At the bottom of one pit I observed very hard typical pinel with boulders, underlying stratified sand and gravel. In another pit a bed like pinel and nearly as hard, but stratified, rose up to the surface in the form of a semi-arch. Another pit revealed obliquely bedded gravel and sand; a fourth pit, dark sand under compact gravel. The beds in all the pits were very much contorted; the pinel here and there seemed to run into beds of compact gravel; and in other respects the drifts resembled those of the Ulverstone railway-section. A farmer told me that a knoll to the S.W. consisted of similar sand and gravel. The altitude of these drifts is between 200 and 300 feet above the sea. In the valley of the Crake an ochreous drift with numerous scratched boulders runs down to the level of the river; and in this district we find an illustration of a fact which I believe to be of universal application in all districts containing erratic boulders: the rivers or brooks have nothing to do with the drifts lying in or near their courses further than reassorting them over very limited areas. It ought not to be forgotten that in North-west Lancashire (and, I believe, in many other districts) the middle sand and gravel is more frequently found on plains, watersheds, or hill-sides than in what may be strictly called river-valleys *.

g. Pinel at High Levels.—It has just been stated that pinel may be found under the middle drift on the pass between Penny Bridge and Arrad Foot. Near to Beckside hamlet a good instance of its frequent mode of occurrence at high levels may be seen. It occupies small hollows in slate rocks with planed-off edges. Pinel runs up the sides of the hills to considerable altitudes between Beckside hamlet and Ulverstone, and in some places it looks like an old sea-beach or the remnant of a once extensive deposit still fringing or clinging to the mountain-slopes. About Lindal pinel may here and there be seen exposed in pit- and road-sections at levels varying from 250 feet to upwards of 300 feet above the sea; but much of of what is called loose pinel in this district is probably upper drift.

* The pinel in hilly countries occurs frequently at the bottom of valleys and gullies, from which it thins out upwards along the slopes.

On walking from Ulverstone to Beckside village (Kirkby Ireleth district), over the intervening hilly region, the pinel may be traced almost continuously. On ascending the hill the gutter in the road-side reveals about the hardest and most typical pinel I have yet seen. Its colour is almost invariably yellowish brown. Valleys have been filled up with it to a certain height; and brooks have excavated their channels in it. Beyond a house called Harlock, and along the east and north side of a round hill called Longslack, it runs continuously, and presents all the most typical characteristics of the formation, including large striated boulders. In most places it seems to have been covered to a slight depth with loose angular detritus. The pinel covers the greater part of the watershed of the flat shallow pass between the Longslack and Crag-Height eminences, where it reaches an altitude of about 800 feet above the sea. It may be traced running down the western side of the pass, where it has not been covered with Upper Boulder-clay. It may possibly run under the estuary of the Duddon so as to form a more or less continuous deposit with the pinel on the other or Cumberland side of the river. The accumulation of the pinel mantling round Longslack, and probably many of the neighbouring hills, might at first sight suggest the idea of a great flow of land-ice ignoring hill and valley; and yet there would appear to be some difficulty in supposing land-ice capable of leaving a continuous spread of pinel clinging to the convex side of a hill and covering a wide shallow pass, as in the locality under consideration.

h. Upper Boulder-clay.—Where the ground begins to decline on the western side of the above pass, the pinel gradually dips beneath a rubbly clay. Lower down, on the Soutergate-road-side, at a height of about 700 feet above the sea, the line of demarcation between the pinel and this clay is very distinctly marked. Still lower down this clay presents features which can leave no doubt that it is of Upper-Boulder age. The channel excavated in it by the Cross beck reveals a thickness of at least 100 feet. In several places it may be seen resting on the denuded edges of slate rocks. It contains many smoothed, polished, and striated boulders. At a lower level, on the road-side, pinel occasionally makes its appearance underneath this upper drift. The pinel is hard and of a yellowish-brown colour*; the upper drift loose and of a reddish colour. At a still lower level a small boulder of granite, a sign, I believe, of Upper Boulder-clay in this district (see sequel), made its appearance; and all along there were many boulders of porphyry and other rocks, which must have been floated across the valley intervening between this hill-side and the green slate and porphyry mountains. On many of the boulders the striæ were bent across each other in a remarkable manner. At a small quarry above Gargreave, and about 250 feet above the sea, I saw the edges of compact slate rocks planed down and slightly grooved, the direction of the glaciation being 10° W. of N., or ob-

* On the other side of the depression traversed by the Cross beck, as may be seen on the Beckside road, the upper drift has in most places thinned out, the pinel coming to the surface.

liquely to the slope of the hill. This looked like an instance of glaciation by the grounding of floating ice during the Upper-Boulder-clay period. Between the base of the slope and Dunnerholme, though stones of granite &c. may be found, few sections of drift have been exposed, so as to reveal the distinction between Boulder-clay and postglacial or recent marine deposits.

i. Drift Capping of Dunnerholme.—Dunnerholme is surrounded on three sides by sea, and on one side by land which has evidently been sea at no very remote period. The limestone strata mainly dip S.W., but towards the western side S.E. It is cliffed all round. The highest part of this semi-island is about 70 feet above the sea. It is more or less covered with Upper Boulder-drift from 2 to 5 feet thick. The drift, a red loamy clay, is well charged with rounded and half-rounded stones, many of them much more rounded than those now washed by the sea at the foot of the cliff. The stones consist of slate, porphyry, &c., with a small percentage of granite. The drift rests on a smoothed, hollowed, and funnelled limestone-surface, as before remarked. It is difficult to explain the presence of drift in such a perched position without supposing that the plateau once graduated into the neighbouring ground, and that since the deposition of the drift the sea has encroached all round so as to leave a bounding line of cliff. But if so, the conclusion can scarcely be resisted that isolated drift-covered plateaux in inland and upland regions must have been circumdenuded by the sea.

On the road between Dunnerholme and Dalton granitic boulders are common. Upper Boulder-clay, with its usual accompaniment of brick-pits, undoubtedly runs along the shore of the Duddon estuary to Barrow; but in the central part of the Furness peninsula the drift (where it is not decided pinel or cleanly washed sand and gravel) is so tinged with red oxide of iron from the older hæmatitic deposits, and is so inconstant in its character, as to render the task of correlating it very difficult. It varies from angular detritus and red loam to red gravelly clay. On the watershed between Ulverstone and Barrow the furthest east specimen of granitic drift I could find was near the village of Stainton. But though granite in Furness may be regarded as an indication of Upper Boulder-clay, it does not follow that the upper-drift sea extended no further eastwards, but merely that the ice-laden current from the mountain source of the granite had here its boundary. I have not seen the clay on the coast at Rampside, near the southern point of the Furness peninsula, but, from information received, have no doubt that it is of Upper-Boulder age. Neither have I seen the sand hills to the south-east of Barrow.

j. Upper Boulder-clay at Barrow.—At the Dalton-road brick-pit, Barrow, the Upper Boulder-clay appears in such full force as to justify the epithet applied to it in the S.E. of England by Mr. Searles V. Wood, jun.,—“ *The* Boulder-clay.” As usual it is comparatively sandy, soft, or loose in the upper part, and more argillaceous or marly and solid lower down. Near the surface, it is here of a dun bluish-brown colour, the bluish tinge increasing downwards. Its thickness varies from 40 to 60 feet. An intelligent Scotchman, who had been concerned in well-sinking, informed me that at a depth of 60 feet under this clay the drift was found to consist of a layer of sand with water, a layer of fine bluish clay, a layer of fine gravel, and a layer of sand (middle sand and gravel?). The distinction between this Boulder-clay and pinel was sufficiently manifest. Unlike pinel, which is packed full of stones of all sizes up to a certain diameter, the stones were sparingly distributed through the clay under notice, and, with the exception of the large boulders, a number of the stones taken out of it at random, and gathered into a heap, exhibited a wonderful approximation to uniformity of size. In one heap the average diameter was from 5 to 6 inches. This looked as if the stones, *previously* assorted, had been brought from a sea-beach by floating ice, and here dropped into the clay as it was accumulating. I was able to trace this clay for a considerable distance N.E. on the Dalton road. What appears to be a continuation of it may be seen between Dalton railway-station and the tunnel, overlying a pebbly gravel.*

k. Surface Boulders.—There is a very large boulder of porphyry lying on the surface in a square not far from Barrow railway-station; but it was on Stainton Green, near the centre of the Furness penininsula, that I met with the most extraordinary array of enormous boulders in close proximity I have anywhere seen remote from a hill-side from which they conld have fallen, and in a situation where no valley-glacier could have left them. The largest was about 18 × 12 × 4; but Mr. Bolton (a meritorious local geologist) informed me that three or four stones, at least twice as large, had been blasted and used for building. The lower part of the boulders was imbedded in ochreous drift. They were more or less rounded and smoothly sculptured, the sculpturing, as before stated, running down under the stones. In some places they were polished. Here and there smooth basins and furrows had evidently been *ground* out. One curvilinear channel, not only smooth but almost polished, was two feet deep. On one side of it, and opening downwards, a smooth circular small hole presented a fac-simile of a part of a *Pholas*-burrow. The possible derivation of these boulders could easily be traced; for a limestone cliff consisting of rounded, basined, and channelled blocks might be seen three or four hundred yards off, from which they were probably floated by ice.

l. Sections obtained by borings near Ireleth.—As a means of ascertaining the succession of deposits, bore-holes are seldom to be relied on; but, in connexion with the question of the triplex division of the drifts in Furness, it may be important to give a section of one

* I had little time to notice the Postglacial deposits of the Furness peninsula. They consist principally of a bluish or greyish warp or clay, which partly fills up the low-level valleys, and runs round knolls of glacial drift—and of a formation, more or less consolidated, of sand and shells, which I have reason to believe cannot be referred to any particular period, though it is certainly newer than the Upper Boulder-clay, and in many places older than the recent beach-sand and shingle. I have only seen it on the beach, at the mouth of a brook, near Seawood.

of the Ireleth Iron Company's bore-holes at Askham Wood, near Ireleth railway-station, in the basin of the Duddon (it was kindly furnished to me by Mr. Salmon, F.G.S.; the foot-notes are my own):—

	feet.
Sand	15
* Dark Clay	51
† Gravel, 9; Clay, 3; Quicksand, 6; Clay, 5	23
† Quicksand	21
‡ Brown Clay	181
§ Brown Limestone, 6; Brown Clay, 11; Limestone, 13; stopped in Brown Clay	30
	321

6. Drifts of Whicham Valley and Blackcombe.

On the way from Green Road station to Blackcombe, near a hamlet called the Green, a gravel-pit in the side of a mound shows a section of real typical hard pinel with sand-seams. I was informed that in the neighbourhood there was often a considerable thickness of sand under the pinel. On arriving at the mouth of the Whicham Mill ravine, which runs up into the heart of Blackcombe, I was somewhat surprised to find a considerable thickness of pinel graduating upwards into what, for want of a better name, I shall call chip- and splinter-drift. Still higher up, the sides of the ravine seemed to consist of pinel, hard at the bottom, and looser towards the top. Immense boulders of porphyry || were here and there exposed in the channel of the brook. The boulders were both rounded and angular. The drift higher up the narrow ravine, so far as its nature could be observed, presented the appearance of a mass of triturated slate, clay, and sand. Where the brook from the upland cwm or corry joins the main stream, the drift might pass for Upper Boulder-clay, though it may be only a looser part of the pinel which probably exists underneath. But up to this point it maintains the charater of an undoubted *drift*. It

* Upper Boulder-clay?

† Variegated middle sand and gravel?

‡ Lower Boulder-clay?

§ Decomposed limestone, such as is found in the Boulder-clay of some of the Iron-ore pits in the Lindal district?

|| As protrusions or dykes of porphyry have been found in this neighbourhood, we have no need to suppose that these boulders were carried over Blackcombe from the north.

may formerly have extended quite across the ravine, and the missing part may have been ploughed out by a glacier, or washed away by the brook, or most probably removed by both. After a steep climb, the floor of the dark and deep corry is reached. At its head there are undoubted traces of local glacial action, though it is difficult to say how far the moraine matter may not have been arranged under the waters of the sea. In the middle, what looks like a small conical hill from below rises up and forms the barrier of a swampy plateau covered with rushes, which may be the site of a former small lake. Between the conical mound and a moraine-like accumulation on the N.W. side, there is a breach, which may mark the outlet of the supposed small lake. On the S.E. side a great mass of fine débris runs up the steep slope. On the N.W. side of the basin-shaped head of the corry, the base of the steep cliffs of Skiddaw slate is concealed under a series of chip and splinter deltas which point upwards to the vertical gutters or "rakes" down which the detritus must have fallen or been carried by rain. I mention this to show the difficulty of distinguishing glacial moraine matter from common "screes" in narrow mountain-recesses *.

On ascending the south side of the corry, and after walking over the brow of the hill, I descended towards Whicham through Black-Crag ravine, and was not surprised to find the mouth of this ravine choked up with drift containing large angular and rounded boulders. Along the base of the south-east escarpment of Blackcombe, and filling up the greater part of the length and breadth of Whicham Valley, there is an undulating broad terrace of drift, which near the hill-side rises up gradually and regularly, like an old tidal zone, and stretches into the ravines and cwms of the mountain. So far as can be seen, the lower part of this drift consists, at least in many places, of pinel. Thick deposits of sand and gravel apparently constitute its mass. In some places these deposits are capped with a reddish clay. The small brook which runs down from the semicircular cwm behind Whicham parsonage has made a well-defined rut in the longitudinally level terrace, and exposed a section of alternating layers of loam, clay, sand, and rounded shingle, in some places resting on pinel. At a lower level, near Whicham Hall, a pit-section in a gently swelling knoll reveals thick masses of sand and gravel, the latter containing pebbles of granite, quartz (from the S.E. slope of Blackcombe?), &c., many of them extra-rounded; granite seems to predominate.

At the S.W. end of Whicham valley there are several sand and gravel hillocks; and Mr. Salmon, F.G.S., informs me that in this neighbourhood, some time ago, a bore-hole was stopped in about 300 feet of sand. Between the Whicham drift-terrace and Millom Hill, there is a flat depression, like a tidal channel, covered with recent deposits. Its bottom is only slightly elevated above the present sea-level. On the N.W. side of the low eminence called Holborn Hill (on which

* For remarks on the distinction between moraines and screes in the valleys f the Coniston Fells, see the author's 'Scenery of England and Wales,' Excursion xx.

a new village has lately sprung up) I noticed a considerable spread of decided Upper Boulder-clay. At the top of the eminence, in a quarry, a deposit of stratified sand and gravel rests immediately on the smoothly shaved-off edges of inclined beds or laminæ of slate.

7. Direction and Derivation of the Flow of Granitic Drift in N.W. Lancashire.

A line running from about Bootle in a south-easterly direction across Morecambe Bay, and along the north-eastern side of the drift plain between Preston and Longridge, would perhaps roughly indicate the north-eastern border of the granitic drift of North-west Lancashire*. In the Furness and Whicham areas I have traced it as far N.E. as Whicham Hall (as already stated), Holborn Hill, the neighbourhood of Soutergate, and Stainton Green. The north-eastern border of the ice-laden current which carried the granite would appear to have been more or less winding. The current must have set in before the close of the period of deposition of the Blackpool Lower Boulder-clay, if not earlier, and must have continued to flow till the close of the Upper Boulder-clay period. The same current may have supplied the granitic drift of the Cheshire and Shropshire plains, a great part of Staffordshire, a part of Worcestershire, &c. But if so, it seems unreasonable to look to the limited sea-coast area which Eskdale could have furnished (even admitting a series of different levels) as the sole or even the principal source of the granitic drift †. A current could not have flowed from the north over the high ground at the head of Eskdale into and along the course of the valley at the time when its granitic slopes were above water. A great current passing by the mouth of the valley, would not be likely to become loaded to a greater extent with the granite of the valley than with the rocks impinging on the previous and following parts of its course. If so, it appears difficult to explain the great preponderance of granitic boulders in many parts of the extensive drift-area just mentioned by appealing solely or even principally to Eskdale in Cumberland; and such being the case, where are we to look for the other source or sources of the granitic drift so widely distributed over the west of England? To the south of Scotland, or to some part of Ireland? Without wishing to support the theory of the Irish derivation of any part of the granite, I may state:—that the Rev. Maxwell H. Close is of opinion that chalk flints found in the drift of Shropshire came from Ireland; that I have seen chalk flints in the drift of west Cheshire nearer to Ireland; and that a chalk flint has been found at an altitude of nearly 1000 feet above the sea, on Holcombe Hill, near Manchester ‡. These remarks, made perhaps partly in ignorance of

* Boulders of granite from Shap Fell may possibly be found in the drift to the north of this line.

† I have been informed that Shap granite may be found on the west coast of Lancashire; but this would merely show that granite may have been floated from the Shap Fells into the course of the great N.W. and S.E. current.

‡ Mr. Aitken, Trans. Geol. Soc. Man. vol. vii.

what is already known, are merely intended to stimulate to further research*.

8. Connexion between Boulder-drifts and Superficial Accumulations at high Levels.

I have not seen any Lower Boulder-clay or pinel in the Furness peninsula at a higher level than nearly 800 feet above the sea (between Ulverstone and Beckside). In the valleys and on the slopes of the Coniston Old Man, I have traced it up to about 900 feet near Paddy-End Copper Works, and to about 1200 feet on the Walna Scar road and between it and Goat's Water. The Upper Boulder-clay of Furness may be traced up to at least 700 feet (above Soutergate). On the Old Man I have traced a coarse rubbly clay overlying either pinel or sand and gravel up to at least 1200 feet above the sea. On the same mountain, rounded gravel may be found up to 1000 feet†. In south Lancashire Mr. Hull has not been able to trace the undoubted Lower Boulder-clay up to any considerable height. The middle drift rises higher‡, and the Upper Boulder-clay higher still, while erratics may be found on the Pennine hills up to 1800 feet, proving a submergence of north-central England to that extent§. I believe I saw a patch of erratic Upper Boulder-clay, at least 1000 feet above the sea, at the entrance of the railway tunnel north of Dove Holes (near Buxton), Derbyshire. But from an examination of the extent to which drift deposits, with erratic stones, graduate upwards into deposits with angular stones of local derivation, and from a comparison of the superficial accumulations at low and high levels in Lancashire and Derbyshire, I have been led to the following conclusions:—

(1) During the period of the great north and south flow of land-ice, superficial detritus, either loose or closely packed, was left in hollows or on the lee side of rocky projections and knolls; but no extensive and continuous spread of Boulder-clay resulted from its action.

(2) During the succeeding submergence the sea rearranged the previously existing surface-detritus, and combined with land-ice in giving rise to a variety of superficial phenomena of denudation and deposition, which will require much research to decipher.

(3) The principal part of what are called drift deposits was derived from the waste of local rock formations, and accumulated by the ordinary action of the sea. In most places, especially at a distance from hills, comparatively little of the finer part of drift deposits

* The Rev. Mr. Thornber informed me that Connemara Marble (?) had been found in the Boulder-clay at Blackpool; and a workman once showed me a specimen of *Gryphæa incurva* he had picked up on the beach. The latter may possibly have been brought to Blackpool as ballast in a vessel.

† For an account of the drifts of the Old Man see 'Scenery of England and Wales,' by the author of this paper.

‡ It is well known that shell-bearing middle drift has been found in the neighbourhood of Macclesfield, and on the Macclesfield and Buxton road, up to 1200 feet above the sea.

§ Mem. Lit. and Phil. Soc. Manchester, vol. ii. 3rd series.

was brought to the sea by glaciers, or floated by ice. Most of the rounded larger stones, excepting where they are the remains of sea-beaches *in situ,* were carried from sea-coasts by floating ice, and dropped with or without finer drift matter into ordinary marine deposits then in course of being accumulated. In many places these deposits lay out of the way of receiving additions from floating ice.

(4) Marine deposits extend up hill-sides, cover upland valleys and plateaux, and stretch along the bases of escarpments (as in Derbyshire) where few or no erratic boulders or stones are to be found. At high levels the identity of these deposits with so-called drifts is rendered probable by the fact that the finer matter composing them is seldom entirely*, though generally mainly, of local derivation, and likewise by the fact that they graduate by imperceptible degrees into erratic drifts at lower levels.

(5) The absence of rounded stones in superficial accumulations, at high levels, may be attributed to the positions in which they occur having been unfavourable to littoral attrition, or to the sea having not continued long at a stationary level. Though the angular stones in these accumulations are local, they often occupy positions to which they must have been drifted from short distances.

(6) Unless the term *drift* be limited to erratic stones contained in clay, sand, and gravel, the general covering of hilly districts†, so far as it is distinct from merely fallen or washed-down detritus, freshwater alluvium, and the effect of disintegration *in situ,* ought to be included in the term drift deposits.

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7. *On the* Connexion *of the* Geological Structure *and* Physical Features *of the* South-east *of* England *with the* Consumption Death-rate. By W. Whitaker, Esq., B.A., F.G.S.

[Abstract.]

The author stated that his investigation of this subject, which was carried on in conjunction with Dr. Buchanan, was suggested by the

* In Derbyshire, near Buxton, the limestone is covered with a brown clay graduating into sandy loam, which in some places is scarcely distinguishable from the covering of the Yoredale and Millstone-Grit strata of the neighbourhood, and both may be found graduating into drift deposits with erratic stones at lower levels. The clay on the limestone is distinct in colour and composition from the underlying coating of decomposed limestone. The latter is produced by the chemical action of the rain-water which the clay prevents from running off. Here, as in the Furness district, smoothly sculptured rock-surfaces, where they are covered with clay, are becoming minutely pitted and disfigured by pluvio-chemical action. These surfaces, under dry loam, or in the open air (where rain-water quickly runs off), are smoothly, regularly, and curvilinearly hollowed, rounded, basined, channelled, and funnelled.

† The marine origin of the general detrital covering of elevated areas in Scotland is admitted by Mr. James Nicol (Quart. Journ. Geol. Soc. vol. xxv. p. 283) and by Mr. James Geikie (Geol. Mag. vol. v. pp. 22, 23), who speaks of "angular Gravel" and "mounds of débris" on hill-sides as having been accumulated by the sea.

fact that improved drainage had been found to exert a marked influence upon the average number of deaths by consumption in certain districts. The chief result arrived at by an examination of fifty-eight registration districts in Kent and Sussex was, that "wetness of the soil is a great cause of consumption;" and this depends not only upon the perviousness or imperviousness of the soils, but upon their position as regards elevation and slope.

Discussion.

Prof. Brayley mentioned a paper by Mr. Mackinnon on the same subject, communicated to the Royal Society some years ago.

Dr. Duncan commented on the value of such inquiries, and mentioned that in Devonshire families living in the valleys were peculiarly liable to consumption, while those living on the hills were free from the disease.

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8. *On the* Volcanic Phenomena *of* Hawaii. By the Rev. C. G. Williamson. Communicated by Sir R. I. Murchison, Bart., F.R.S., V.P.G.S.

[Abstract.]

The author describes the general configuration of the island of Hawaii, and refers especially to the arrangement of the three great volcanic cones which form its highest points. Mount Kea (13,953 feet) and Hualalai (10,000 feet) have been quiescent for many years*; but Mount Loa (13,760 feet) is still in a state of constant activity. In the extreme north of the island is the Kohala ridge of cones (about 5000 feet), which appear to have been long extinct. The bases of the three great volcanoes, which stand nearly in an equilateral triangle, are united by an elevated plateau forming the centre of the island, sparingly clothed with vegetation, and having many conical hills, from which lava appears to have flowed, scattered over it. In descending from the high grounds there is a belt of woods, in which the vegetation gradually becomes more tropical in its character; and this continues to be the case on the lowlands to the coast. The fertile districts are all within the limit of rains; and here the older lavas, of which the surface consists, are more or less decomposed. The author describes the general characters of the surface, and states that the greatest alteration of the surface has taken place in the northern parts of the island; hence he concludes that the centre of volcanic energy in the island has gradually been moving southward, the outpourings from the Kohala hills and Mount Kea, which have undergone most alteration, being, in his opinion, the oldest, and the southernmost volcano, that of Mount Loa (including Kilauea), being the only one now in activity.

The author notices the history of the activity of Mount Loa since the year 1832, when its first recorded eruption took place. A

* The last eruption of Hualalai took place in 1801.

considerable eruption and lava-flow occurred in 1843, another of less consequence in 1851; and in 1852 a great lava-stream issued from the side of the mountain, at an elevation of about 10,000 feet, and flowed westwards for about thirty miles without reaching the sea. In 1855–56 the most extensive eruption on record occurred. The lava issued from a fissure on the western slope of Mount Loa, at an elevation of about 12,000 feet, flowed first in a north-westerly direction down to the central plateau, and then, turning westward, took the direction of Hilo. This lava-stream flowed for thirteen months, travelled a distance of sixty miles, and covered nearly 300 square miles of ground. In 1859 an eruption commenced at an elevation of about 9000 feet, from a crater 500 feet in diameter; the flow of lava continued for six months, passing across the central plateau in a north-easterly direction, skirting the volcano of Hualalai, and reaching the shore between Kiholo and Wainaualii, where it forms a distinct promontory. This lava-stream destroyed the village of Kiholo. The chief lava-flows from Mount Loa have taken a more or less northerly direction; and the author ascribes the lavas of the south-western portion of the island, especially the district of Puna, to the activity of the great crater of Kilauea (elevation 3970 feet), the appearance of which he describes. Eruptions of Kilauea took place, according to the author, in 1789 (consisting of sand and ashes without lava), 1823, and 1840.

The author notices particularly the great earthquakes and other volcanic phenomena of the year 1868. The first earthquake occurred on the evening of the 17th January; and the shocks continued to be felt, with more or less severity and frequency, throughout the year. The author noted those observed by him, with particulars of the time of the day at which they occurred and the strength of the shocks. The shocks were most frequent from the 28th March to the 6th April, during which period they appear, from the author's Tables, to have been almost incessant. His general results are summed up in the following Table:—

Month.	Very Heavy.	Heavy.	Moderate.	Light.	Total.
January	„	„	„	1	1
February	„	„	1	„	1
March	3	14	39	68	124
April	6	21	96	77	200
May	„	„	4	1	5
June	....	No	record	kept*.	....
July	„	1	„	5	6
August	„	„	1	7	8
September	„	1	3	9	13
October	„	„	1	3	4
November	„	„	1	„	1
December	„	1	3	2	6
Grand total	9	38	149	173	369

* The author having been absent from Hawaii.

The greatest earthquake-shock took place on the 2nd April, at 3.40 P.M. The author describes this as excessively severe: the whole island appeared as if it were being shaken to pieces; walls and houses were thrown down, great masses of rock were precipitated from the cliffs, and large trees were broken off. Simultaneously with this earthquake a great mud-eruption is said to have taken place at Kapapala, although the author considers that the phenomenon really consisted in the casting down of a hill-top upon the plain. The débris extended over a space about three miles long, and varying from 500 yards to one mile in width. Over this space houses and cattle were buried, and 31 persons are said to have lost their lives. Immediately afterwards a stream of fresh water rushed down the hill-side, and continued to flow permanently. The author suggests that the sudden explosion by which this great earth-fall was produced may have been caused by the contact of water with the hot lava under the surface of the ground.

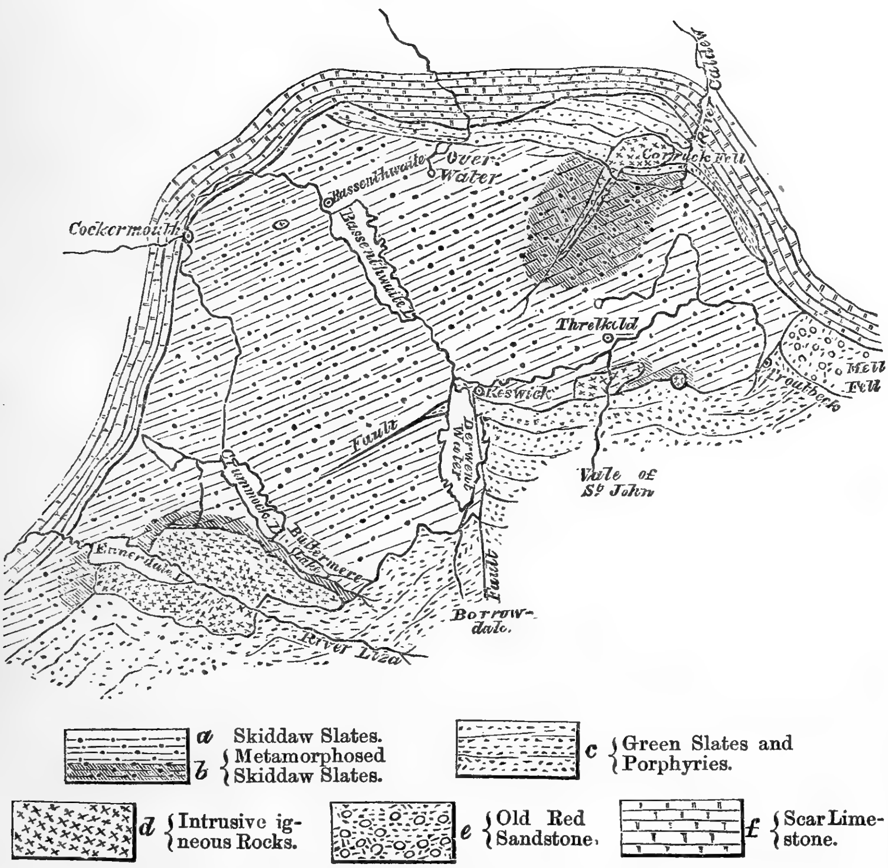
On the 7th April a rent opened high up on Mount Loa, and from this lava flowed. In the afternoon of the same day a fissure appeared in a hill about ten miles from the sea, in the district of Kahuku, near the southernmost point of the island. From this a stream of the smooth satin-like lava called "pahochoe" in Hawaii flowed for a few hours, and then stopped. Another stream, of larger size, and consisting of the rough, porous lava known locally as "aa," burst forth in the neighbourhood of that just mentioned, but about two miles nearer to the sea; it issued immediately behind the farmstead of the proprietor of Kahuku, which it immediately destroyed, and afterwards flowed down to the sea until the 12th of April, consuming everything in its course. About 250 head of cattle were burnt up. The lava was described to the author as issuing from the ground in four enormous jets. The smoke and sulphurous vapour emitted during this eruption darkened and poisoned the air for a great distance around it. Soon after noon on the 4th of April, an earthquake-shock, almost equal to that of the 2nd, was felt; and this seemed to have affected the basin of Kilauea, which had previously been unusually active; for the lava-lakes sank down, and the fires gradually died out, until, on the 7th of April, none were to be observed. The coincidence of this sudden sinking of the lava in the crater of Kilauea with the breaking out of the great lava-stream at Kahuku, forty miles distant, seems, to the author, to indicate an intimate connexion between the two phenomena.

The great earthquake of the 2nd of April was accompanied by a destructive sea-wave, which washed away several villages, and destroyed many lives. The whole south shore of the island has been permanently depressed, in some places as much as 7 feet, but on the average about 4½ feet.

9. *Notes on* CERTAIN *of the* INTRUSIVE IGNEOUS ROCKS *of the* LAKE-DISTRICT. By HENRY ALLEYNE NICHOLSON, M.D., D.Sc., M.A., F.G.S.

THE rocks which I purpose noticing in the following communication are certain igneous rocks, of an intrusive character, and holding an almost identical position in the stratified series of the Lake-district of Cumberland and Westmoreland. The rocks in question are the syenite of the Vale of St. John, the syenitic porphyry of Ennerdale and Buttermere, and the felstone porphyry of Carrock Fell, all of which come into contact, on the one hand, with the Skiddaw Slates, and on the other with the series of the green slates and porphyries.

Fig. 1.—*Sketch Map of the North-western portion of the Lake District.*



I. *The Syenite of the Vale of St. John.*

The area occupied by the main exposure of this rock is situated on both sides of the mouth of the Vale of St. John, distant about three miles to the east of Keswick, and occupying a space of nearly two miles from east to west by nearly a mile from north to south. On the east side of the valley it forms a cluster of minor elevations, of which the highest is known as Knotts. On this side of the valley the syenite, in its main mass, nowhere comes into contact with the green slates and porphyries, but is everywhere surrounded by the upper beds of the Skiddaw Slates, which are often more or less indurated and penetrated by numerous small veins of quartz near the line of junction. It is well exhibited in a quarry about a quarter of a mile to the S.E. of Threlkeld Station, where it is so regularly jointed as to assume the aspect of a bedded rock, the joint-surfaces dipping E.N.E. at 50°. In appearance it is of a light greyish colour, some specimens being almost white. It consists of a felspathic base, enclosing numerous large crystals of a greenish-white felspar, with many small specks of hornblende and little masses of transparent crystalline quartz, together with occasional crystals of garnet. The rock has also imbedded in it a great abundance of angular fragments, some of which consist of trap, whilst others are laminated and almost gneissic, and appear to be derived from the Skiddaw Slates. On the opposite or western side of the Vale of St. John the syenite forms the whole of Low Rigg, and can be traced southwards as far as the chapel of St. John, at which point it is overlain by a green felspathic trap, which forms the base of the green slate series. No alteration, however, is observable in the trap near the line of junction. It has been largely worked near Hollin Root, where it is very regularly jointed and possesses the same mineral characters as near Threlkeld Station, except that in parts the base becomes red, and its aspect thus becomes more decidedly syenitic.

About a mile and a half to the east of the Vale of St. John, close to where Mosedale Beck crosses the road between Matterdale and Threlkeld, there occurs an intrusive mass of felstone, which is undoubtedly an extension of the syenite seen near Threlkeld Station. It is a greyish-white, granular, felspathic rock, in parts very regularly jointed, often containing cubes of iron pyrites, and rarely exhibiting small masses of quartz. As the quartz, however, is very sparingly developed, and the hornblende has entirely disappeared, it can no longer be called a syenite, but must be looked upon simply as an occasionally quartziferous felstone. On the north and north-west the upper shaly beds of the Skiddaw Slates come into contact with this intrusive boss, and are somewhat decolorized, and even slightly brecciated near the line of junction. To the south the felstone is overlain by the trap which forms the base of the green slate series, but without the production of any perceptible alteration.

In connexion with the syenite of the Vale of St. John, I must allude to a remarkable felstone dyke, which is apparently derived from the syenite. The dyke in question was first noticed by Professor Sedgwick (see 'Letters'), and occurs about a quarter of a mile above Armboth House, in the course of a stream which flows from the west into Thirlmere Lake. It cuts across a series of bedded traps, which form the lower part of the green slates, and appears to strike N.W. and S.E., being seen again close to the Ordnance Cairn, nearly half a mile to the S.E. of its exposure in Armboth Beck. In mineral characters it is very peculiar, consisting of a base of reddish-brown felspar containing numerous large oblong crystals of red felspar and many crystals of quartz, most of which are doubly prismatic. The width of the dyke is about 50 or 60 feet, and for three or four feet on both sides it is altered by contact with the trap through which it cuts. In this altered zone it becomes a compact red felstone, with a few crystals of quartz scattered through it, but without any crystals of felspar.

II. *The Syenitic Porphyry between Ennerdale and Buttermere.*

This syenitic felstone-porphyry forms an intrusive mass of very considerable extent, occupying an area of about six miles from east to west by about three miles from north to south, comprising the mountainous district between the lakes of Buttermere and Ennerdale, the lower half of the valley of the Liza and the mountains to the south of Ennerdale Lake. Commencing at Bowness, a small hamlet situated about midway between the extremities of Ennerdale Water on its north-eastern side, the syenitic porphyry is seen to form Bowness Knot, and to be immediately succeeded on the N.W. by the Skiddaw Slates, which are greatly metamorphosed, and are converted into a hard greenish-grey rock, very compact, and exhibiting few traces of bedding. On the opposite, or south-western, side of the lake the syenitic porphyry is continued nearly to the foot of the lake, being probably shifted to the N.W. by a fault. It forms here the hills known as Crag Fell (or the Revelin) and Angler's Crag, and it is succeeded on the N.W. by the Skiddaw Slates, which form the northern flanks of Grike Fell. From their junction with the syenite for a distance of nearly three-quarters of a mile the Skiddaw Slates are highly metamorphosed, retaining no signs of their sedimentary origin beyond the existence of lamination. They are converted into an extremely hard, granular rock, much penetrated by quartz-veins, of a pink or greenish-grey colour, and finely banded along the lines of lamination. As just stated, the metamorphism in this locality affects a great thickness of the rocks, slates of the normal character not reappearing till Fell End is nearly reached. Returning to Bowness, the boundary of the intrusive rock can be traced between Ennerdale and Buttermere, pretty nearly coinciding with the road between these two lakes by way of Floutern Tarn. Between these points the syenitic porphyry is succeeded to the N.W. and N. by the Skiddaw Slates, and rises on the S.E. and S. into the elevations of Herdhouse, Great Borne (2019 feet), and Gale Fell.

About a mile and a half from Buttermere the cascade of Scale Force is formed over a precipice of this rock. From the foot of Buttermere the intrusive rock can be followed along the south-west margin of the lake, nearly as far as the pass of Scarf Gap. All along this line the Skiddaw Slates are seen striking right against the porphyry, and more or less metamorphosed near the line of contact. The metamorphism does not appear to extend more than a few feet from the porphyry; but within this zone the slates are converted into a hard, laminated, greenish-grey rock. To the S.W. of this line the porphyry rises into the lofty chain of hills which separates Buttermere from Ennerdale, comprising Ling Comb, Red Pike, High Stile (2643 feet), and High Crag. From Scarf Gap the S.E. and S. boundaries of the syenitic mass are continued across the valley of the Liza (about 1½ miles above Gillerthwaite), and thence to the south of Ennerdale Lake by Ling Mell, Iron Crag, and the Side, to the Revelin, all these hills being composed of the intrusive rock. All along these boundaries the syenite is overlain by the traps which form the base of the green slate series, the latter appearing to suffer no alteration near the line of junction.

As regards the mineral characters of this great intrusive mass, they are somewhat different in different localities. In the neighbourhood of Buttermere, and indeed throughout the greater part of its extent, it is merely a quartziferous porphyry, composed of a base of reddish felspar containing numerous crystals of white felspar, with specks of hornblende and grains of quartz disseminated through it. In other localities, however, as at the head of Ennerdale, quartz is present in considerable abundance; and the rock then assumes the characters of a true syenite.

III. *The Felstone-porphyry of Carrock Fell.*

This rock forms the summit and the northern spur of Carrock Fell, near Hesket-new-market, where its occurrence has been described by Prof. Harkness (Quart. Journ. Geol. Soc. vol. xix. p. 124). The area which it occupies is not of any very great extent, being about 1½ mile from E. to W., and about a mile from N. to S. Throughout the greater part of its extent it is surrounded by trappean rocks, which belong to the series of the green slates and porphyries, and which do not appear to have undergone any alteration near the line of contact with the intrusive rock. Its eastern boundary extends from a farm called Stone Ends, near Mosedale, northwards as far as Carrock Beck. Its northern boundary runs up Carrock Beck, and is formed by the traps of West Fell and High Pike, though the junction is nowhere visible. On the south it is bounded by a singular crystalline rock which is seen near Mosedale, and forms a mass of great thickness. At its south-western corner, however, it becomes continuous with a mass of fine-grained granite, which is seen in Grainsgill Beck (Brandy Gill), close to the junction of this stream with the river Caldew. This fine-grained granite is surrounded by metamorphosed, gneissic Skiddaw Slates, which are seen almost in direct contact with it. It is, doubtless, as believed by Prof. Harkness, in turn continuous with the coarse granite which occurs higher up the valley of the Caldew, and which Prof. Sedgwick described under the name of "the Granite of Skiddaw Forest."

Admitting, as seems almost certain, that these three igneous masses are directly connected with one another, and pass into one another without a break, two facts are noticeable:—First, the strike of the igneous masses conforms to that of the stratified rocks amongst which they are situated. Thus the strike of the granite of the Caldew valley is nearly N.E. and S.W., and therefore very nearly agrees with the strike of the Skiddaw Slates in this region. The syenitic porphyry of Carrock Fell, on the other hand, appears to extend itself in a direction from E. to W., this being very nearly the strike of the bedded traps of the green slate series by which it is surrounded. Secondly, the mineral character of the intrusive rock appears to vary with the character of the rocks which surround it. Thus, high up in the valley of the Caldew we find a coarsely crystalline granite lying in the heart of the Skiddaw Slates, the latter being highly metamorphosed for a considerable distance on both sides of the plutonic rock. As we approach the point where the Skiddaw Slates are overlain by the green slates and porphyries, the granite becomes much finer in grain and less highly quartziferous. Finally, as seen in Carrock Fell, where it is surrounded by the traps of the green slate series, it has entirely lost its granitic character, and is now simply a felstone-porphyry. It contains neither quartz nor mica, and is composed of a base of reddish felspar, with crystals of felspar and specks of hornblende, closely resembling, in fact, the syenitic porphyry of Buttermere.

IV. *Age of the Syenite of the Vale of St. John and the Felstone-porphyries of Buttermere and of Carrock Fell.*

In investigating the age of these igneous masses, an important element of the inquiry is found in the discovery which I have recently made (Geol. Mag. vol. vi. Nos. 3 & 4), that the green slates and porphyries are superimposed unconformably upon the Skiddaw Slates, an opposite opinion having been hitherto entertained. The Skiddaw Slates, therefore, were subjected to elevation and denudation before the formation of the green slates and porphyries had been initiated. Bearing this in mind, it is, in the first place, noticeable with regard to the three igneous masses in question, that they occupy a definite and similar position in the stratified series of the Lake-district. They are all found to be in relation, on the one hand, with the Skiddaw Slates, a vast group of purely sedimentary origin, and, on the other hand, with the green slates and porphyries, an equally vast series of volcanic ashes and lavas. The second fact to be noticed is that it is only the inferior sedimentary formation that is metamorphosed, to any perceptible extent, by contact with these intrusive masses. Of course, from the nature of the upper group, any alteration which might be present would be much less conspicuous than in the case of the Skiddaw Slates; but I have not been able to satisfy myself that there occurs any. The Skiddaw Slates, however, are invariably metamorphosed in the neighbourhood of the intrusive rock, this metamorphism affecting in different localities a greater or less thickness of the beds. In the vicinity of Buttermere the alteration in the Skiddaw Slates is comparatively slight in amount, and unaltered slates are found not many yards distant from the intrusive rock. At the foot of Ennerdale, on the other hand, the slates, in contact with the same rock, are altered throughout an enormous thickness, the metamorphism being plainly visible at a distance of half a mile from the syenitic porphyry. In the Caldew valley the metamorphism is still greater, and affects a much greater thickness of the beds.

In the third place, the intrusive masses show a great similarity in their mineral characters. They are all highly felspathic, and the chief difference between them is in the amount of free quartz which they contain, this being, however, variable in different portions of even the same mass. In the syenite of the Vale of St. John, the amount of quartz is tolerably large; but in the syenitic porphyry of Buttermere quartz is much more sparingly developed; and in the felstone-porphyry of Carrock Fell it appears to be entirely wanting.

Fourthly, the series of the green slates and porphyries, where it comes into relation with these intrusive rocks, is distinguished by the absence or thinness of the breccias and ashes, and by the great development of the bedded traps, the former expanding and the latter diminishing in thickness as we get at a distance from the intrusive focus. Thus, the syenite of the Vale of St. John is succeeded to the south by the great series of bedded traps, which extend to the foot of Thirlmere, the breccias and ashes of Borrowdale and Watendlath having entirely thinned out, though they are of great thickness and are situated only a few miles to the S.W. In like manner the felspathic trap, which usually forms the base of the green slate series, and which is generally of small thickness, appears to expand enormously in thickness to the S.W. of the syenitic porphyry of Ennerdale, as is seen in the valley of the Liza. Lastly, the felstone-porphyry of Carrock Fell occurs in connexion with the well-known series of bedded traps which compose the Caldbeck Fells, and which constitute the inferior portion of the green slates in this region.

Fifthly, in the case of one of these intrusive rocks (the felstone-porphyry of Carrock Fell), it seems tolerably certain that there is a gradual passage from a felstone, through a fine-grained granitic rock, into a genuine granite.

Taking the above-mentioned facts into consideration, it appears to me that two theories only could well be advanced to account for the relations which subsist between these intrusive masses and the stratified rocks which lie around them.

It might be held, in the first place, that these intrusive rocks belong in reality to the Skiddaw Slates, the date of their production coinciding with the period in which the Skiddaw Slates were primarily elevated, anterior to the commencement of the deposition of the series of the green slates. In this case the green slates and porphyries would be subsequently deposited upon a denuded surface formed partially of Skiddaw Slates and partially of intrusive igneous rock. To this view there are various objections, the chief being that the intrusive rock in some cases appears to penetrate the superior formation by which it is almost entirely surrounded, as is the case with the felstone-porphyry of Carrock Fell.

The other theory has been well expressed by Professor Ramsay (Mem. Geol. Survey, vol. iii. p. 235) with regard to some of the intrusive igneous rocks of the north of Wales; and it certainly appears to me to be the one which applies to the rocks in question in the Lake-district. He says:—"Lying, as they invariably do, either amid the true volcanic rocks or in lower stratigraphical horizons, and being for the most part felspathic, some of them may well be the deep-seated masses from whence the lavas and ashes of the volcanoes came; and I do not see why this should not hold, even though they may only, in certain instances, have been Cambrian or Lower Silurian strata that passed into a state of fusion."

Upon the whole, then, and in the meanwhile, I should be decidedly disposed to regard this as the true explanation of the phenomena which I have endeavoured to describe in this communication, and to look upon the igneous masses in question as the roots of the ancient vents from which were derived the alternating ashes and traps which together compose almost the whole of the green slate series. Whether they are to be regarded as being produced by an alteration and fusion of the Skiddaw Slates *in situ*, is another question, and one which is at present incapable of solution. Phenomena, however, are not wanting which would appear to favour this view; and evidence sufficient for its establishment may yet be obtained, when the district shall have been examined in greater detail.

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10. *On the* Fossil Myriopods *of the* Coal Formations *of* Nova Scotia *and* England. By Samuel H. Scudder, Esq.

(Communicated by Sir Charles Lyell, Bart., F.R.S., F.G.S.)

[Abstract.]

In this paper the author discussed and described the species of Chilognathous Myriopods which have been detected in the Coal-measures. Of these he recognized 6, viz. *Xylobius sigillariæ* (Daws.), *X. similis*, sp. n., *X. fractus*, sp. n., *X. Dawsonii*, sp. n., *X. Woodwardii* (=*sigillariæ*, Woodw.), and a species upon which he founded a new genus, *Archiulus xylobioides*. He regarded these forms as constituting a peculiar family, for which he proposed the name of *Archiulidæ*.

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11. *On the* Geology *of the* Country surrounding *the* Gulf of Cambay. By Alexander Rogers, Esq., F.G.S., Bombay Civil Service.

(The publication of this paper is deferred.)

[Abstract.]

The author described the surface of the country as consisting chiefly of deep alluvial soils, derived from the denudation of the primary and metamorphic rocks surrounding the district, the former

making their appearance in groups of isolated peaks, projecting, as it were, from a sea of alluvium. The author considered that this alluvium could not have been produced by the action of the existing rivers, and suggested that the Indus may formerly have flowed into the sea by the Gulf of Cambay, the land at the same time being much depressed below its present level. He indicated the evidence in favour of this view furnished by various facts in the geology of the district, and referred especially to the mode of occurrence of laterite.

DISCUSSION.

Sir P. EGERTON mentioned that the Secretary of Mr. Burlinghame, the Chinese Ambassador, had informed him that the course of the Yellow River had, within a comparatively short period, changed its course by nearly 500 miles, and, by cutting off the supply of water to the Great Canal of China, had brought on the Taeping rebellion in consequence of the employment of the people being lost.

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12. *On a* NEW ACRODONT SAURIAN *from the* LOWER CHALK. By JAMES WOOD MASON, Esq. F.G.S., &c. of Queen's College, Oxford.

(PLATE XIX.)

WHILE lately inspecting the rich and instructive collection of cretaceous fossils formed by my friend Mr. J. S. Gardner, F.G.S., my attention was arrested by what I at first sight took, judging from the precisely similar mode of implantation of the teeth, to be the anterior end of the snout of *Mosasaurus*, an extinct marine lizard closely resembling, as is well known, in many important structural characters, existing Monitors and Iguanas, and peculiar, as far as we at present know, to rocks of the Cretaceous period, both in Europe and America. But a closer examination of the teeth alone discovered differences from those of *Mosasaurus* altogether inconsistent with such an identification; the incorrectness of this becomes quite evident after the comparison which, thanks to the valuable researches of Dr. Leidy, it is possible to make of the fragment under consideration with the corresponding portion of the snout of *Mosasaurus*; it can further be seen from Dr. Leidy's* specimen that the structure of the fore part of the face of *Mosasaurus* differed in no essential particular from that of *Monitor niloticus*.

The fossil consists of the whole of the left præmaxilla † together with some portion of the contiguous maxilla; but, owing to the total obliteration of the maxillo-premaxillary suture, it is impossible to arrive at any satisfactory conclusion as to the extent of the former. The bone is so broken away posteriorly that no portion of the contour of the orbit is preserved, neither is the smallest guide furnished as to its position relatively to the aperture of the anterior nares. Its

* Cretaceous Reptiles of the United States, p. 39, pl. xix. fig. 6.

† It may be that the præmaxilla is absent.

Fig. 1.

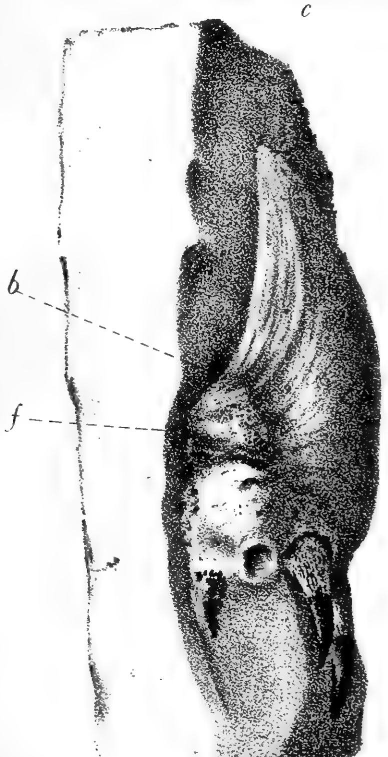

Fig. 2.

Fig. 3.

De Wilde lith. M & N Hanhart imp.

total length is four inches; its outer face is convex in every direction, but more strongly so from above downwards near the anterior end, and is marked by a longitudinal groove running parallel to, and at a distance of about a fourth of an inch from the upwardly curved dentigerous border: this groove (Pl. XIX. fig. 1, *g*), doubtless, gave lodgement to a vessel and a branch of the fifth pair of nerves from which neuro-vascular filaments were sent off for the supply of the teeth through the foramina that pierce the bottom of the groove. Numerous vascular foramina stud the surface of the bone near the end, which is flattened into a facet (figs. 1, 2, *f*) looking upwards and forwards: above, it presents for its posterior half a thin irregular fractured edge; its greatest depth is measured from the angle formed by the junction of this fractured edge with a natural free edge which, sloping downwards and forwards, and curving very little outwards, forms the left lateral boundary of the external nasal aperture.

The removal of a small portion of the matrix revealed the existence of a small bony projection (figs. 1, 2, *b*) from the inner face; this met with a similar projection from the opposite præmaxilla, and furnishes evidence that the points at any rate of the *non*-confluent præmaxillæ entered into the nasal aperture; but whether they were so extended upwards and backwards in the middle line as to meet in lacertine fashion the forward prolongation of the nasals, the limited extent of my materials will not allow me to determine.

The dentigerous edge (= outer alveolar wall) supports eight teeth, the posterior of which only exhibit perfect bony union of their bases with the alveolar margin; the rest are less firmly united to their shallow sockets. This creature evidently had two teeth in front on each side of the middle line; the remains of the inner of these were disclosed by the development of the fossil, but the shallow socket of the other is the sole evidence of its existence; immediately behind, and touching the third tooth, is what appears to be the osseous base (fig. 1, *c*) of a shed tooth.

The projection from the inner face at (*a*) in fig. 3, which represents the fractured hind end in section, appears to be the rudiment of what would have been produced inwards and downwards, so as to form the inner alveolar plate, if the teeth had been lodged in a continuous groove or in distinct sockets, and not anchylosed to the terminal border of the external alveolar plate. The teeth are precisely similar in shape to those in the anterior region of the mouth in *Monitor niloticus*; but I do not wish to be understood as suggesting that the posterior teeth were similarly modified for crushing: the smoothness of the enamel is only broken by the faintest trace of folding at the point of its junction with the cement; this is finely furrowed or striated longitudinally, as in the teeth of *Mosasaurus* and *M. niloticus*. The bony bases, which bear nearly the same great proportionate size to the crown as in *Mosasaurus*, were no doubt covered by a gum. The pulp-cavities remain open.

This reptile differs from *Mosasaurus* in the apparently persistent distinctness of the præmaxillæ from each other, and their small development in the middle line, in the more anterior position of the nasal aperture *, which, moreover, in *Mosasaurus* looks directly upwards instead of upwards and forwards, in the total obliteration of the maxillo-præmaxillary suture, which, in *Mosasaurus*, remains as a well-defined groove, and, lastly, in the absence from its cylindrical teeth of the opposite denticulated ridges, the total range of variation in the teeth of *Mosasaurus* including at most teeth exhibiting the suppression of one of these (the anterior), and that on the pterygoid teeth †.

I propose for this reptile the name of *Acrodontosaurus Gardneri*—the first obviously in allusion to the mode of attachment of its teeth, the second out of compliment to my indefatigable friend.

The strata of the locality whence this fossil came were so fully and ably described by my friend Mr. Etheridge in fixing the position of *Acanthopholis horridus*, Huxley, that it will only be necessary to say that it was obtained by Mr. Griffiths from the Lower Chalk of Lyddon's Spout, near Folkestone, about 10 feet above the Chalk marl.

It will, I think, be better to leave the discussion of the affinities of this reptile till further discoveries furnish a better character for our guidance than the mode of implantation of the teeth.

EXPLANATION OF PLATE XIX.

Fig. 1. Side view of upper jaw of *Acrodontosaurus Gardneri*, nat. size: *b*, process of præmaxilla; *c*, osseous base of shed tooth; *f*, terminal facet; *g*, groove.
2. Front view of the same: *b* & *f* as in fig. 1.
3. View of fractured hinder end: *a*, inner projection.

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13. Rodentia *of the* Somerset Caves.

By W. Ayshford Sanford, Esq., F.G.S.

(The publication of this paper is deferred.)

[Abstract.]

The author has examined the Rodents from the caves of Somersetshire contained in the Taunton Museum, and found that many of them cannot be referred to species hitherto regarded as belonging to the fauna contemporary with the Mammoth in Britain. He enumerates species of *Arvicola* (including *A. glareola*, Schreb., and *A. ratticeps*, Blas.=*Lemmus medius*, Nilsson, and a species which may be new, and for which he proposed the provisional name of *A. Gulielmi*), *Lemmus* (*L. norvegicus*, Desm.), *Lagomys* (*L. spelæus*, Owen), *Lepus* (*L. diluvianus*, Pict., *L. timidus*, Linn., *L. hibernicus*, Bell, and *L. cuniculus*, Linn.), *Spermophilus* (*S. erythrogonoides*, Falc.: the citation of *S. citillus* by the author and Mr. Boyd Dawkins is founded on a mistake), and *Cricetus* (*C. songarus*, Pall.).

* Goldfuss in Nova Acta Acad. Nat. Cur. vol. xxi. p. 1, tab. vi.–viii.

† *Teste* Dr. Leidy.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. *On a* Peculiar Instance *of* Intraglacial Erosion *near* Norwich. By Searles V. Wood, Junr., Esq., F.G.S., and F. W. Harmer, Esq., F.G.S.

(Read April 14, 1869*.)

The object of the present brief notice is to bring before the Society, while the works are in progress, a feature of intraglacial structure disclosed by the sewerage works at Norwich, in order that, since the case appears to us to be peculiar among the perplexing features presented by the glacial beds as far as yet known, the opportunity may be afforded, to any who may suspect that some mistake has been made, of investigating the accuracy of our representation before the means of doing so are removed. For this reason we have ventured to bring the subject forward now, instead of reserving it for description with the general glacial structure of the east of England, which we hope at some future time to lay before the Society.

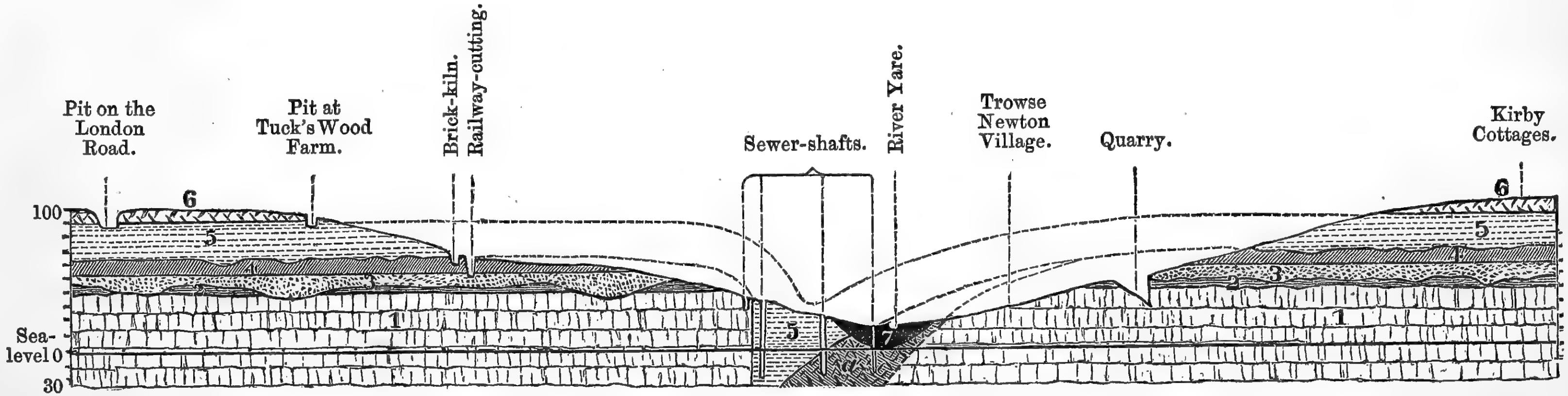
All the valleys of Suffolk, and of Central and Eastern Norfolk, are excavated out of the glacial beds, and possess no connexion whatever with any preglacial condition of the surface. They appear, however, to have had their configuration and direction determined in several places by a denudation of the glacial beds themselves, which was effected during the progress of their deposit. Of this the case before us affords one instance.

The accompanying section shows the structure of the valley of the Yare, near the places of its inosculation with that of the Tese and that of the Wensum.

The sewer-works, up to the present time, have been carried on by shafts, sunk in the bottom of the valley, where the surface is considerably below the line maintained by the chalk on either of its sides. These shafts have disclosed that a hole or, it may be, a narrow trough in this part descends abruptly, and almost perpendicularly, into the chalk, and that in it lies, not merely one of the successive beds (5) which form the solid mass of the country around, but also another bed which does not appear to exist elsewhere in the neigh-

* For the Discussion on this paper, see p. 260 of the present volume.

Section across the Yare Valley at Trowse.



The chalk 1 forms the fundamental stratum. 2 is the Chillesford sand and clay. 3 is the pebbly sand and pebble-beds which succeed to that clay, and which expand northwards into the Weybourne sand and Boulder Till of the Cromer-Cliff section; this bed is unconformable to the Crag and Chillesford beds, is palæontologically distinct from them, and is characterized by the first appearance in England of *Tellina Balthica.* 4 is the "contorted drift," here uncontorted, and about 15 feet thick, being only a sixth or seventh part of the thickness which it attains in the north of Norfolk and in the Cromer Cliff. 5 is the Middle Glacial sand. 6 is the Boulder-clay, or Upper Glacial. And 7 is a Postglacial valley-gravel that has a much greater development a short distance further down the valley. The alluvium is included in 7.

bourhood. This bed is that distinguished in the section by the letter *a*, and it consists of dark-blue clay full of chalk-débris, exactly resembling the Boulder-clay (6) in parts distant from Norwich, but different from the appearance presented by that clay in the neighbourhood of the section, where it is much more chalky There is, we think, no question as to the identity of the sand which reposes on this bed, in the hole, with that numbered 5, in the group of beds out of which the valley is excavated, since it possesses the peculiar admixture of fine chalk grains possessed by this sand in the various sections of the immediate neighbourhood, as well as generally in the south-east of Norfolk, and offers a complete contrast to the postglacial gravel (7).

Assuming the bed *a* really to underlie No. 5, as represented in the section, the case is not without parallel elsewhere, though there are but two other localities of its similar occurrence at present known with certainty to us. One of these is Witham, in Essex*, and the other the vicinity of Hertford, mentioned by Mr. Hughes†, in both of which it seems to occur at the base of 5, in a trough which had been formed prior to the accumulation of that deposit, but which in those cases does not appear to be coincident with the existing valleys.

We forbear to discuss here the causes which seem to us to have given rise to this bed, or which have produced the intraglacial erosion of the hole, or trough, in which it has thus been preserved, as these will be more conveniently considered in connexion with the general glacial structure of the east of England, further than to observe that we trace in it the action of a glacier ‡. The features disclosed by the section appear to show that after the bed 4 had been deposited, an erosion took place just here which swept out the beds 2, 3, and 4, and excavated the deep hole or trough (whichever it be) in the chalk in which we now find the bed *a*. Whether this bed was deposited only in the hole or trough thus formed, or whether it spread generally over 4 in these counties, and then was denuded prior to the deposit of the sands 5, we have not yet formed a decided opinion; but the physical break which the case before us seems to show, occurred here between the termination of the uppermost deposit of the Lower Glacial period, represented by bed 4, and the commencement of the Middle, represented by bed 5, concurs with what we find in this respect in many places in Norfolk and North Suffolk, since there is generally an unconformity between the bed 4, or its marl representative, and beds

* The first notice of it at this place was in a well-section given by the Rev. O. Fisher, in Geol. Mag. vol. v. p. 98. We have since found it exposed in section about a mile from Witham, in the bottom of the valley.

† Quart. Journ. Geol. Soc. vol. xxiv. p. 286.

‡ In the discussion on this paper I admitted that the erosion in question might have been produced by a grounding berg. I withdraw that admission altogether, believing, from a study of the respective formations over East Anglia, that after the beds forming the Lower Glacial series had been converted into land, this land became extensively occupied by ice before it was again depressed to receive the sea, which deposited the Middle Glacial sands; and that to such land-ice the erosion in question is due.—S. V. W., Jun.

5 and 6. Thus, for instance, on the Cromer coast, we find the former most deeply and irregularly indented by troughs filled with the base of 5, both deposits being there in much greater thickness than in the case before us; while in the inland sections we find it rising through 5 in bosses of greater or less extent, the Boulder-clay (6) being spread there over it and over 5, sometimes resting on the one and sometimes on the other, thus showing 4 to have formed either islands or shoals in the Middle Glacial sea.

The intraglacial denudation of the Yare valley, disclosed by the sewer-works, serves to explain a feature brought before the Society by one of us in 1866*. In that case a bed of Boulder-clay was shown lying in the bottom of the Yare valley, and described as a third Boulder-clay. Although, at the time, we both regarded it as distinct from the great Boulder-clay (6), we now incline to think that the bed in question is either the bed *a*, or else merely the Boulder-clay 6 brought down into the bottom of the valley by a repetition of the denudation which, we have just seen, commenced after the deposit of the contorted drift 4. The dotted lines in our section represent probably the way in which 5 bent down into this hollow of denudation; and it seems to us that the denudation was renewed after the deposit of 5, sweeping out so much of that bed as had been deposited in the hollow, but leaving it in the hole or trough which is shown in our section, and thus allowing 6 to be thrown down upon the chalk direct, as shown in the section referred to†.

In the adjoining valley of the Wensum a somewhat similar state of things has occurred, as we have found there the Middle Glacial sand (5) overlain by the Boulder-clay (6) in a hole in the chalk, and resting directly upon it, below the level of bed 3, which, in that part, forms the general base of the formations superior to the chalk, and constituting the solid mass of the country.

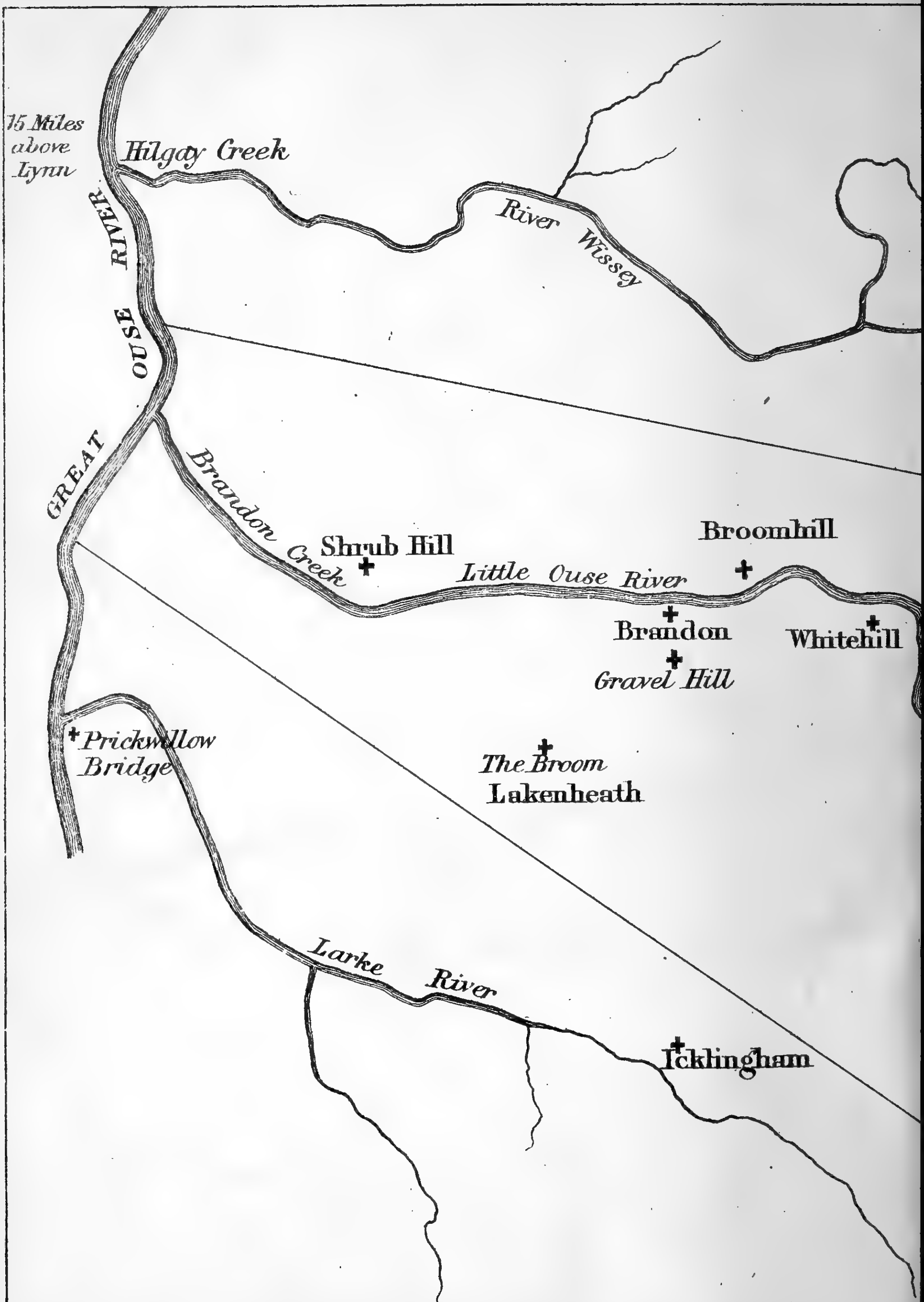
No infiltration or slipping can explain these features, because the blue clay (*a* of the accompanying section) is not, so far as any of the pits around disclose, present in the neighbourhood, and because the deposits which underlie the beds in question, when in their usual position, do not occur beneath them when thus abnormally placed, although, in the case of the blue clay *a*, we ought to add that the shafts do not reach its base, so that it is unknown whether anything intervenes between it and the chalk.

In conclusion, we would venture to remark that the sections referred to appear to us to militate against the excavation of our East-Anglian valleys by river-agency, as well as to show the illusory character of the level-test as applied to the elucidation of the age of the newer Tertiaries, especially of those occurring in valleys; although we are far from saying that the evidence of level, when kept in due subordination to other features, has not its value.

Note.—This paper was postponed in the hope that the progress of the works would have brought further facts to light; but nothing

* Quart. Journ. Geol. Soc. vol. xxiii. p. 89.

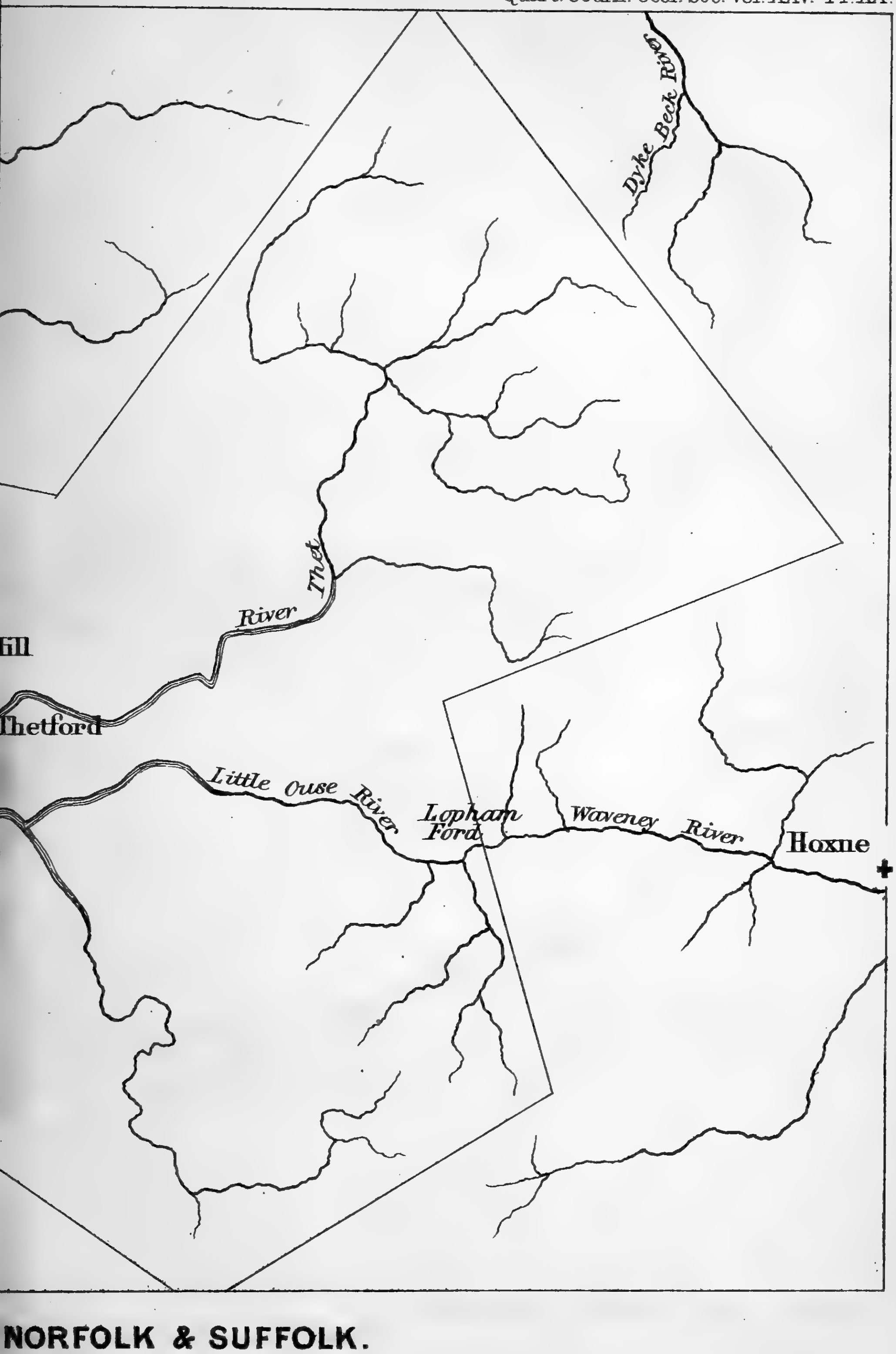
† Ibid. See the bed *a* of that section, which is not to be confounded with the bed *a* of the section which accompanies the present paper.



F Dungerfield, lith: 22, Bedford St Covent Garden.

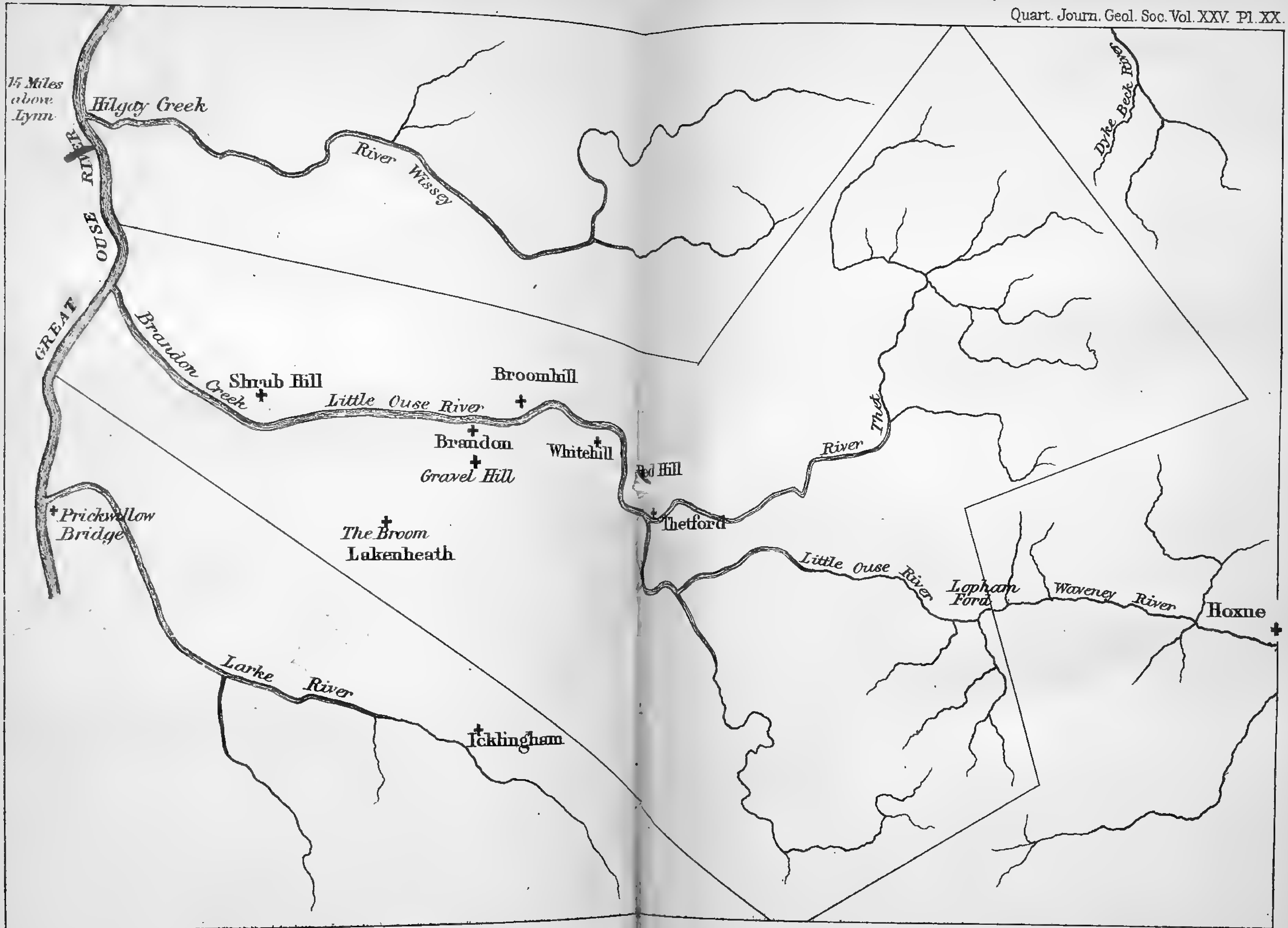
SKETCH MAP OF PART

Scale abou



NORFOLK & SUFFOLK.

to One Mile.



F. Dangerfield, lith.: 22, Bedford St. Covent Garden.

SKETCH MAP OF PARTS OF NORFOLK & SUFFOLK.

Scale about 1 inch to One Mile.

further has transpired. It is not impossible that the bed *a* may, instead of underlying, be bedded vertically against No. 5, and that the shaft, after passing through No. 5, encountered a lateral protrusion of *a*. If so, there would be no reason for regarding *a* as anything else than the bed No. 6, which it resembles in parts distant from Norwich.

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2. *On some recent* Discoveries *of* Flint Implements *of the* Drift *in* Norfolk *and* Suffolk, *with observations on the Theories accounting for their Distribution.* By J. W. Flower, Esq., F.G.S.

(Read April 28, 1869 *.)

[Plate XX.]

In June 1866 I had the honour to lay before the Society a paper upon some flint implements then lately found at Thetford in the valley of the Little Ouse river †; I have lately occupied myself with further investigations of the same district, the results of which, are, I trust, of sufficient interest to justify me in bringing them to the notice of the Society.

The localities which I have now examined are four in number. In each of these flint implements have been found, and in several of them in great abundance, corresponding in the main, as well in fashion as in material, with those of St. Acheul, Thetford, Salisbury, and Icklingham, which are now so well known.

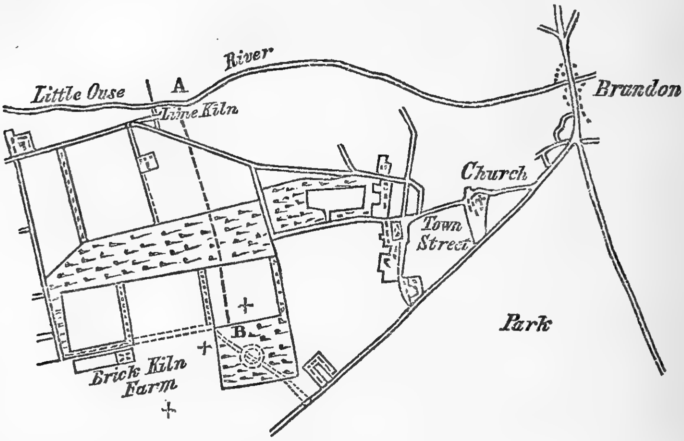
Broomhill.—The first deposit which I have to notice is found at Broomhill, on the north bank of the river, about five miles from Thetford, and two from Santon Downham mentioned in my former paper. The implements, which are usually much rolled and worn, and are often stained to a chocolate-colour, are here found in a gravel-pit about 350 feet from the river-bank. They are usually met with in a bed of ferruginous flint-gravel about 2 feet thick, resting immediately on the surface of the chalk, and 5 or 6 feet above the level of the river. This gravel, which is very coarse and not much rolled, contains large flint nodules, some of them weighing over a hundredweight, and is mixed with rounded quartzite pebbles and rolled fragments of chalk. It is overlain by another stratum of gravel, less ferruginous and containing a greater proportion of broken chalk; and this bed, in its turn, is capped by a mass of siliceous sand, sparingly intermixed with angular flints of no great dimensions. These several beds constitute a mass of from 25 to 30 feet in thickness. No gravel is found on the opposite bank; the ground there, which is moor or fen, rises very slightly above the river-surface, and forms a plain extending about half a mile to the base of the chalk-hills.

Gravel Hill, Brandon.—At this place, situate two miles and a half west of Broomhill and on the Suffolk side of the river, another

* For the Discussion on this paper, see p. 272 of the present volume.
† Quart. Journ. Geol. Soc. vol. xxiii. p. 45.

deposit is met with, the position of which, however, is essentially different from that found at Broomhill. From a careful survey which

Plan of Gravel Hill, Brandon.



+ Gravel-pits.—Height 90·62 feet, from A to B, taken from the level of the river. Distance from the river 78 chains.

I have lately made it is found to be 91 feet above the river, and very nearly a mile distant from it at the nearest point; it comprises an area of from thirty to forty acres, occupying the summit of a hill overlooking an extensive sandy plain, which at a short distance merges in the great level of the fens. The bed of gravel here is usually not more than 10 feet in thickness, and often less, resting immediately upon the chalk; and, as at Broomhill, the implements are usually found at the bottom of it, and occasionally they lie upon the chalk. As regards its composition, however, no less than its position, this gravel differs greatly from that found at Brandon; the nodules of flint are not so large, there is very little of the broken chalk, and the mass of the overlying sand is much less.

By far the larger proportion (perhaps three-fourths of the whole mass of gravel) consists of rounded quartzites, and a few jasper-pebbles, while at Broomhill the proportion of these is hardly a thirtieth part of the whole. In some spots, indeed, these pebbles form a compact mass with hardly a single flint; and under one of these, at a depth of 6 feet, I procured a very well-shaped implement. The implements here are not generally stained of so deep a colour as those at Broomhill; and while many of them are of very coarse workmanship, and much worn and broken, others are of excellent forms, and as sharp and fresh as when first made.

Lakenheath.—The next deposit which I have examined is at Lakenheath, Suffolk, distant three miles from the left bank of the river. It is found on some high ground known as the Broom, between Lakenheath and Eriswell, and is at about the same height above the river, and of the same character as that at Gravel Hill, from which it is separated only by a shallow valley. These hills are only two miles and a half apart, and the beds which now cap them were doubtless at one time continuous. There is not so much quartzite and jasper here, nor is the gravel so ferruginous as at Brandon; and being worked for the parish roads, and not for sale, as in the other pits, fewer flint implements have been obtained from it. The gravel extends over an area of about 60 acres, and lies immediately upon the chalk, to the same depth as at Brandon—8 to 10 feet.

Shrub Hill, Feltwell.—This deposit differs materially from the others; it is found on a farm known as Shrub Hill farm, situate in the fen on the Norfolk side of the river, and about eight miles below Gravel Hill. The implements occur in, or rather beneath, a patch of coarse flint-gravel and sand, which is apparently completely isolated. The chalk is here wanting, and the gravel, which is spread over an area of more than twenty acres, reposes immediately upon the surface of the gault. This bed, which is now extensively worked, was until lately quite unknown, the gault and the gravel being alike effectually concealed by the great bed of peat which just covers them. Although not laid down in any map, this gault is evidently a continuation of the bed, portions of which are shown in the Society's map, at Downham, Cambridgeshire, to the south, and Stoke Ferry, Norfolk, to the north.

The gravel here is about 12 feet in thickness, but at the surface it is only 6 feet above the river. The implements here, as at the several other places above described, are, with very few exceptions, found at the bottom of the gravel, and not seldom they are lying upon the surface of the gault; they are usually much worn and rolled, and occur in considerable numbers: the gravel here is unstratified, and contains much less quartzite than at Brandon, and the overlying sands do not attain to so great a thickness.

Both at Broomhill and Brandon, as well as at Shrub, the implements are found in considerable quantities; I have procured several hundred specimens, sometimes as many as a hundred at a time. Other collectors have also visited the pits, and I have no doubt that there have been at least 1500 specimens procured from them within the last two years. When it is considered how many must escape the notice of the workmen, we may well believe that the valley of the Little Ouse is as prolific of these objects as that of the Somme, if not more so.

It has been usual hitherto to consider them as divisible into three kinds,—the flakes, the pointed, and the ovoid; but several others may, I think, now be distinguished. One implement, from Shrub Hill, which was found on the surface of the gault, is probably the largest yet discovered in England or France; it is 11½ ins. long, and its circumference at the thickest part is 13 inches. Two of those procured from Brandon are formed from quartzite-pebbles similar to those among which they are imbedded. Mr. John Evans has also found one of the same material, although of a somewhat different form, and he has obtained a well-shaped implement of diorite from the same place; in each of these a portion of the original surface remains. These, I believe, are the only instances in which such materials are known to have been used in England for implements of this age. With these exceptions, all the specimens that have been found were formed from nodules of chalk-flint which it is probable had previously been long exposed upon the surface. Many of the flints found with the implements have been fractured by internal expansion, resulting probably from atmospheric influences; some of the implements themselves have been made from stones thus broken, and others were broken by the same means afterwards. Many points and butts are also found, which doubtless were broken in the process of manufacture, the fractured surface retaining precisely the same patina or stain as the worked surface.

Although the implements of this district bear a certain general resemblance to those with which we are familiar from the Somme, as well as to those of Salisbury, and Hoxne, and Icklingham, I think that some slight differences may be detected as regards shape and workmanship; and indeed it seems by no means certain that the implements found at Broomhill do not differ from those at Brandon. Thus at the former place they are often of a wedge-like form, resembling rudely a shoe or foot with a high instep, a variety which is not found at Brandon; while at the latter pits they sometimes occur of a large leaf-like pattern, about 8 inches long by 4 wide and only 2 inches thick at the thickest end, tapering off to $\frac{1}{4}$ of an inch. I have never met at Shrub Hill or Broomhill with any others of this form. In other localities differences have been noticed in the implements found in deposits quite as near to each other as these. Those of St. Acheul differ from those found at Montiers; and Mr. E. T. Stevens, who has so carefully studied the Wiltshire implements, assures me that the group found at Bemerton is of a type decidedly different from those at Milford Hill, a mile and a half distant, and that both of these differ from those found at Hill Head in Hampshire. Possibly each place may have had its own workmen, and perhaps in some cases different shapes were used to meet different requirements. It would be inconvenient to attempt here to give a detailed account of these differences; and, indeed, much longer and more careful observation is needed before we can arrive at any certain conclusions on the subject.

No shells, either fluviatile or marine, have as yet been discovered in either of the several deposits above described; but since my former paper was published, I have found at Thetford a thin seam of fine white sand, with a few land and freshwater shells, lying some feet above the gravel in which the implements occur. Two teeth of *Elephas primigenius*, as well as some bones of *Bos Urus*, have also been found in the Thetford gravel; and from Shrub Hill I have some fragments of the horns of deer, and teeth of some ruminant, probably deer also, as well as some teeth of a small species of horse, all much broken and rolled; with these exceptions I believe that no mammalian remains have hitherto been noticed in these beds, nor any other traces of man's presence than the flint and stone implements.

The geography of the district, with reference to other places in the neighbourhood in which implements have been found, will be understood by reference to the accompanying map (Pl. XX.). At about three miles distance from Broomhill and Brandon, on the north, a high tableland, of about a mile in width, divides the valley of the Little Ouse from that of the Wissey (which flows in the same direction). This hill (which forms the watershed of both rivers) is capped with drift-gravel and siliceous sands closely resembling those seen at Brandon, the quartzite pebbles, however, being somewhat less abundant*. On the south side the river is bounded for some distance by the hills at Brandon and Lakenheath, on which the implements occur; and about seven miles further south, in the Larke Valley, at Icklingham, another well-known deposit of implements has been met with. West of these several localities is seen the great level of the Fens, extending through Norfolk, Suffolk, Cambridgeshire, and Huntingdonshire into Northamptonshire and Lincolnshire, while to the eastward, passing by Santon Downham and Thetford, the Little Ouse is traced back to its source at Lopham Ford; and closely adjoining to the source, and only separated from it by a bank of sand 5 or 6 feet high and 200 yards wide, is found the source of the Waveney, which after running north-east, passing by Hoxne (another locality for flint implements), falls into the sea at Yarmouth †. There seems to be little doubt that these valleys (of the Ouse and the Waveney) are derived from one continuous valley of submarine erosion, by which Norfolk was formerly cut off from the rest of the kingdom, and constituted an island.

We have clear evidence that even within the historical period the district to the westward through which the river flows, after leaving Brandon, was at a much lower level than at present, the valley having been filled up with peat, and thus brought to a dead level, or nearly so, extending over many hundred square miles. Polished flint implements of the Neolithic period have been often found lying below the peat or low down in it, as well as bronze celts and spear-heads; the peat varies in thickness from 1 or 2 feet to 20 or even 30 feet, and in it are found querns of pudding-stone and Roman antiquities. In many places in the level of the fens other unmistakeable proofs have been met with of the comparatively recent origin of these beds. In one place swaths of grass lying just as they were mown were found at the depth of 8 feet, and in other places, at depths varying from 10 to 20 feet, there have been found a smith's forge with his tools and horseshoes, tan-pits, a cart-wheel, and ancient causeways, and the skeletons of sea-fish, and boats or

* Since this paper was read, I have visited this place in company with Mr. Prestwich. He considers this gravel to belong to the Boulder-clay series; and we certainly saw a capping of clay about a foot thick covering a portion of it. The implement-bearing gravel at Brandon is precisely of the same composition, although the quartzite-pebbles occur in much more compact masses. Mr. Prestwich, however, considers it to be a reconstructed gravel, and of subsequent date to that in the watershed.

† In the map published lately by the Society, Lopham Ford is stated to be only 15 feet above high-water mark at Lynn; but this is probably a mistake: the river at Brandon is found to be 15 feet above high-water mark, and the source at Lopham Ford is probably about eight feet higher.

canoes. It also appears, from the depositions of witnesses laid before Parliament in 1696 in support of a petition for the removal of Denver Sluice, that, prior to 1650, when the sluice was erected, the tide flowed twenty-four miles further than it then did into "the deep rivers of Ouse, Stoke (the Wissey), Grant (the Cam), and Mildenhall (the Larke);" and one witness deposed that before the dam was built the tide flowed up to Wilton Lode, which is just two miles from Brandon, and at the foot of the hill above described *.

From these details it will be seen that these beds in every material particular bear a close resemblance to those of the Somme, which have been so well described by Mr. Prestwich. In each, the implements are for the most part found in a bed of coarse flint-gravel, which rests immediately upon the chalk, and is overlain by other masses of gravel and siliceous and calcareous sands. In both deposits the implements are of the same material, the same, or nearly the same fashion, in similar condition, and associated also with similar mammalian remains, and each is destitute of those fossils which are wanting in the other. This remarkable correspondence between these beds in the South-east of England and those of the north of France not only tends to confirm the opinion which has been formed on other grounds, that at the commencement of the Quaternary epoch the two countries had not been severed, but leads to the belief that even at this early period they were inhabited by man.

Nor is the resemblance which these valleys bear to each other confined to the lower beds. In both, as we approach the coast, and at about the same distance from it, the drift-gravel is overlain by a thick bed of peat, which entombs the remains of ancient forests of similar character, and in either country is found to contain similar mammalian remains, associated with implements or weapons of like material and workmanship. We have thus the same evidence in both countries that the first known stage of the Quaternary period has passed away, and a new and well-defined era has arrived. In England, as in France, the great Pachyderms have entirely disappeared, and are succeeded by a new fauna adapted to new conditions, and to be superseded in due time by other creatures and other conditions. As the Beaver, Wild Boar, *Bos longifrons*, the Roe, and the Red Deer have replaced the Elephant, the Rhinoceros, and the Hippopotamus, so instead of the rude implements fabricated by the men who were contemporary with these animals, the fens of Norfolk and Cambridgeshire as well as those of Picardy are found to contain the polished flint and stone implements of a far later period, and pudding-stone querns of precisely similar material and form.

Such being the phenomena presented to our notice, it remains to consider what light they throw upon the origin and history of the implements. Hitherto it has been usual to place them in the same category with the beds in, or beneath, which they occur; they are

* The confluence of the Little Ouse or Brandon river with the Great Ouse is still known by its ancient name as Brandon *Creek*, while that of the Wissey is known as Hilgay *Creek*.

regarded merely as the characteristic fossils of certain river-valley gravels, without reference to the condition of either previous to their being brought together. But although the conditions of either deposit can hardly fail to throw light upon the history of the other, each has undoubtedly a history and (geologically) a date of its own; the implements, although *in* the gravel, are not *of* it, except in a certain limited sense. The one is the product of human skill, the other the result of natural causes; and it is essential to consider them separately, as well as in their connexion with each other.

When first observed, the implements had always been found in the immediate neighbourhood of river-channels, and assuming (as it seems usually to have been assumed) that they had been carried from the places in which they were made, it was reasonable to ascribe their transport to those rivers; but this was but a presumption which, however reasonable, was liable to be rebutted. Because certain objects are found in or near the banks of rivers, it by no means follows that they must of necessity have been carried thither *by* the rivers; they may have been deposited by other means, and possibly even before the rivers had an existence, and there seems good reason for believing that as regards many, or indeed most, of these flint implements this may have been the case.

At the commencement of the Quaternary epoch, when, by the retiring of the sea, or the elevation of its bed, the Cretaceous and Tertiary strata became dry land, it cannot be doubted that the surface, in many places, was, as it still remains, strewn, especially in valleys and hollows, with fragments of various rocks—the wreck and ruin of beds which had been broken up and dispersed. Of these a large proportion would consist of nodules of flint which had been washed out of the upper chalk-beds, or from which the chalk had been removed by decomposition. Abundant materials would thus be provided for the makers of implements and weapons, and the followers of this primitive industry would naturally resort to those spots on which the best material was to be found. The condition in which we find them is quite consistent with the belief that the stone from which the implements were formed had previously been long exposed upon the surface. At one time, therefore, the raw material and the manufactured were alike lying upon the surface, and after some interval of unknown but probably very extended duration, both were alike overwhelmed by those masses of sand and gravel beneath which we now see them. This interval doubtless involved important changes, including perhaps the obliteration of ancient river-channels and the formation of new ones.

If, as has been sometimes supposed, the implements were carried about by river-floods, or by deluges, whether marine or of fresh water, we should expect to find them confusedly intermingled with the sands and gravels, and they would be strewn continuously along the whole course of the valleys. This, however, seems not to be the case; for although the gravel-beds are continuous (frequently for several miles), the implements hitherto have been found only at detached spots, often far apart, and which were probably visited on account of convenience of access or better materials. And instead of being blended with the higher beds (with some exceptions, which are probably attributable to the displacement and reconstruction of the original deposit), they are found in the lowermost stratum—that which rests immediately upon the Cretaceous or Tertiary beds, and which would be left bare when these became dry land.

It is true that occasionally, although comparatively rarely, implements are found lying above the lowest bed; but this is not inconsistent with the belief that they were originally deposited at the lower level, which I regard as their ordinary or normal position. Unlike marine deposits, which are usually those of accretion, the changes which are effected by river- or deluge-agency are those of denudation and dislocation; and it is evident that after the lowest stratum was constituted it was overwhelmed by other very considerable masses, which could only have been transported by powerful torrents. These, in their course, conveying rocks of considerable magnitude, could not fail to some extent to break up the subjacent beds, and in this way some implements would be taken from their first place of deposit, and left at relatively higher levels. As every inundation disturbs, and partially, if not entirely, effaces the traces of that which preceded it, so the upper portion of any bed may be carried away and form a new deposit, upon which the lower portion may afterwards be thrown, and thus the position of each becomes reversed. The worn appearance of some specimens, as compared with the fresh and sharp condition of others, tends to show that, while the latter have been but little, if at all, displaced, the former have been subjected to much rolling and attrition.

The circumstance that some implements are found lying above the lowermost stratum of gravel is thus not inconsistent with the belief that the stones from which they were wrought were nevertheless taken from that bed, and that they are thus to be ascribed to the commencement of the Quaternary period. On the other hand, if we should reject this view, we should be forced to conclude that the process of manufacture was continued through the very lengthened periods that would be requisite for the excavation of the existing river-valleys, involving the assumption, so difficult of acceptance, that although these implements were fabricated and used by many successive generations, they all passed away without leaving any other trace of their existence; and we must also suppose a constant recurrence of those agencies, whatever they may have been, by means of which these things were buried under thick masses of gravel and sand.

Under all the circumstances, therefore, it seems probable that the implements for the most part were not transported by any river or flood, but that they were made, or left, at or near the spots where we find them, although in some instances, especially in valleys and watercourses, they may have been afterwards displaced.

But even if it were otherwise, if it were certain that they were brought into their present position at the same time with the beds of gravel in which they occur, and by the same means, the belief that those beds were deposited by the agency of rivers involves so many difficulties and objections, that it can hardly be accepted without much further consideration than the subject has received, much as it has been discussed. Indeed, unless we are prepared to admit that *all* the Quaternary gravels were brought to their present places of deposit by the agency of rivers (which is evidently impossible), it is unreasonable to attribute to that agency any particular portion of those gravels merely because they happen to contain implements.

Considerable differences of opinion exist between French and English geologists as to the causes which led to the accumulation and distribution of those superficial drifts in the south-east of England and north of France of which the flint-implement-bearing beds form part: while the French geologists unanimously attribute them to some kind of cataclysmal or diluvial action (although they differ among themselves as to its particular character), the English geologists are nearly unanimous in ascribing them to the action of existing rivers, or at least of rivers which then ran in the same direction as they now do, and drained the same areas. The present is not a convenient occasion for considering this subject at any length. I propose only to show how inadequate, as it seems to me, is the theory of fluviatile transport to explain the condition of the deposits before referred to and of others of a like character.

The opinion of English writers cannot be better stated than in the words of Mr. Prestwich, from the able and exhaustive memoir upon the flint-implement deposits read by him before the Royal Society in 1862. He says, "that certain beds of gravel, at various levels, follow the course of the present valleys, and have a direction of transport coincident with that of the present rivers, and that the extent and situation of some of these beds so much above existing valleys and river-channels, combined with their organic remains, point to a former condition of things when such levels constituted the lowest ground over which the waters passed;" further, "that the size and quantity of débris afford evidence of great transporting power; while the presence of fine silt, with land shells, covering all the different gravel-beds, and running up the combes and capping the summit of some of the adjacent hills to far above the level of the highest of these beds, points to floods of extraordinary magnitude;" that "these conditions, taken as a whole, are compatible only with the action of rivers flowing in the direction of the present rivers, and in operation before the existing valleys were excavated through the higher plains, of power and volume far greater than the present rivers, and dependent upon climatal causes distinct from those now prevailing in these latitudes"; and he adds that "such a result might formerly have been obtained, 1st, by a direct increase in the rainfall; 2ndly, by the accumulation and rapid melting of the winter snow, or by the two causes combined; and 3rdly, by the fall of rain in the spring while the ground was in a frozen state."

Mr. Prestwich's opinions have been acquiesced in both by Sir Charles Lyell and Sir John Lubbock. The latter, in his preface to the recent English edition of Sven Nilsson's 'Primitive Inhabitants of Scandinavia,' when speaking of the antiquities referable to the Palæolithic age, says "that they are usually found in beds of gravel and loess, extending along our valleys, and reaching to a height of 200 feet above the present water-level;" and he adds, "that these beds were deposited by the existing rivers, which then ran in the same direction as at present, and drained the same areas."

As long as it was believed that the implement-bearing gravels were never found except on or very near to the banks of rivers, it was reasonable to attribute to those rivers the transport of the gravel in which they were imbedded; but from more recent observations, both in England and France, it seems evident that the implement-bearing gravels, as well as others of the same character, which are not yet known to contain implements, do occur in localities so far removed from existing rivers, and, when found near rivers, at such elevations as almost to preclude the belief that those rivers, however swollen by excessive rainfall or melting snow, or otherwise, could have at all affected their condition.

Thus, for instance, as we see at Brandon, the implement-deposit occurs at an elevation of from 80 to 90 feet above that at Broomhill (which is two miles higher up the stream), and about the same above Shrub Hill, which is several miles lower down. Yet, notwithstanding this great difference in the levels, we have strong, if not unmistakeable indications, derived in some measure from the implements themselves, that all these deposits were (geologically) contemporaneous. The implements in each are substantially of the same age and character; the *matrix* of red gravel, in which they rest, is of the same composition; the beds rest directly upon the eroded surface of the chalk or the gault, and are more or less overlain by sands of the same description. But it is incredible that such deposits (if of the same age), should owe their origin to one and the same river; for if so, in order to reach the higher level, it must have been swollen to the height of 100 feet above the level at Broomhill and Shrub, and extended three miles to the south. This would require a volume of water of dimensions and power several thousand fold greater than those of the present river; and to supply such a stream, the basin from which the river is fed (occupying as it does an area of not more than 300 square miles) is altogether insufficient; nor, indeed, would the present contour of the country allow such a river to flow in that direction.

Nor would the difficulty be removed or lessened if we were to disregard those proofs of contemporaneity to which I have adverted, and to assume that these deposits were separated from each other by an interval of time sufficient to allow of the excavation of the existing river-valley to the depth of the 80 or 90 feet which now divide it from the Brandon bed. We have no reason whatever to believe that, in these districts, the relative levels of the surface have undergone any material change during the Quaternary period*; and, if not, in order to account for the Brandon and Lakenheath deposits, we must suppose that this river once flowed at

* Phil. Trans. 1864, pp. 286–290.

a height at least 100 feet above the present stream, and afterwards altered its course, and flowed several miles to the north. But this could never have been the case: for, just as at Moulin Quignon and Saint Acheul the gravel-beds described by Mr. Prestwich are not commanded by any higher grounds, and are out of reach of all running water, and of any possible interference from agents in present action, so here they are found at an elevation of at least 80 feet above the source of the river, which is not more than twenty miles distant, and there is no high land in the neighbourhood from which a river capable of leaving such a deposit could possibly have been supplied. It is equally clear that if the water had been supplied, it never could have reached to the summit of the hills. These, as I have shown, immediately overlook or overhang the great level of the fens, which was formerly a considerable valley, much of it having been filled up by peat within a period comparatively recent. Before the river could have attained to a height sufficient to submerge the hills and cover them with its spoils, it must have fallen into the low grounds on either side, and, filling up the valley, have found its way to the sea, or, if not, it would have formed an inland lake; in either case the transporting power of the water would have been lost long before it reached the required level.

In confirmation of the views here stated, I may notice that flint-implement-bearing gravels have lately been observed in several other localities, on table-lands and hills far removed from any existing river, and destitute also of the slightest trace of any ancient river.

At the Reculvers they are obtained from a small patch of flint-gravel on a cliff overhanging the sea, and 80 feet above it; while at Hill Head, in Hampshire, and at Bournemouth, Dorset, they have been found in similar situations and at greater elevations.

A still more remarkable instance has been described by Mr. Bruce Foote as occurring near Madras*. The implements here are made from pebbles of quartzite, and in form and workmanship are closely allied to the English and French types. They are found in a red ferruginous clay, known as laterite, which forms a belt eight or ten miles in width, running parallel with the coast-line for the distance of 300 miles. These beds are cut through at intervals, and to great depths, by the rivers of the country running at right angles to the coast-line, and falling into the Bay of Bengal. The implements are never found in the river-channels, except where it is clearly seen that they have been derived from the laterite cliffs. They occur at the height of 500, 1000, and even 1400 feet above tho sea-level, and at this height are associated with enormously large boulder-gravels of quartzite capping the watersheds of the rivers. Like several French and English deposits, these beds rest upon the Cretaceous and Postcretaceous beds; like them they are entirely destitute of marine or freshwater fossils; and, like them also, they are frequently far distant from any river or river-channel †.

* Quart. Journ. Geol, Soc. vol. xxiv. p. 484.

† Since this paper was prepared, Mr. John Evans has shown me three well-shaped flint implements lately found near Southampton, one at the depth of five

The presence of freshwater shells in some of these beds has been regarded as indicative of their fluviatile origin; as far, however, as the evidence at present extends, this condition is the *exception* rather than the rule. When these gravels remain at what I regard as their original place of deposit, viz. immediately upon the chalk or gault surface, I believe that not a single river or lake shell has ever been found associated with them, or lying below them, either in the flint-implement-bearing gravels, or in the very extensive beds of similar gravel in the south and south-east of England and in the north of France, which are not known to contain implements. Certainly no shells have been seen in either of the four deposits above described; nor are there any at the Reculvers, Bournemouth, or Hill Head; and the gravels at Madras are equally destitute of them. The presence of these shells in the *upper* portion of these beds by no means involves the conclusion that they are of the same age as the underlying drift; for, assuming that that was formed and left as above suggested, the valleys and hollows would soon become lakes and rivers, into which in process of time freshwater mollusks would find their way; and whenever the lower beds should be broken up and reconstructed, the shells would be mingled with the débris, and thus become undistinguishable from the older deposits.

Another circumstance which has been relied upon as showing the fluviatile origin of these gravels is the absence of any rocks except those of the district through which the rivers take their course. I do not think that this is very clearly established †; but, assuming it to be so, it is quite consistent with the notion of diluvial transport that the loose objects found on the surface should not be transported out of their own district: rocks and stones, if swept away by a deluge, would very soon find their way into valleys and hollows, and be left there when the waters had retired.

In conclusion I would suggest that the distribution, in the first instance at least, of these drift-beds, containing, as they do, so large an admixture of chalk and tertiary and boulder-clay rocks, may reasonably be attributed to the same forces or conditions, whatever they were, by which the Tertiaries and Boulder-clays were broken up and their materials so widely dispersed and intermingled. We know nothing of these, except from their results; but, whatever they may have been, it seems quite certain that they are not ascribable to fluviatile agency, and I am therefore disposed, with the French geologists, to attribute them to some powerful cataclysmal action, perhaps of short duration, and several times repeated.

feet in flint-gravel. Two were found near the Cemetery, at a height stated to be 110 feet above high-water mark, and a mile distant from the beach; the other was at a spot considerably higher and more inland.

† M. Buteaux, in his very elaborate and careful description of the Somme valley, says that in the diluvium of that valley certain rocks are found which come from the Tertiary beds of the departments of the Oise and Aisne. Mr. Prestwich considers that the quartzite pebbles at Brandon are derived from the Boulder-clay series; but I am not aware that there are any Boulder-clays in the course of the river from which such a mass of these pebbles could have been derived.

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[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

THE END.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the Names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On JURASSIC DEPOSITS *near* VIENNA. By Herr C. GRIESBACH.

[Proceed. Imp. Geol. Institute, Vienna, February 4, 1868.]

THE Jurassic series from the Rhætic formation up to the Neocomian has been found well represented in a circumscribed area near St. Veit, about 2½ miles north-west of Vienna. The Koessen strata are well developed and very fossiliferous; but their stratigraphical relations with the remainder of the Lias could not be ascertained. The Dogger is represented by the zones of *Ammonites Sauzeanus*, *A. Humphriesianus*, and *A. Parkinsoni.* These deposits strike N.E. and S.W., dipping N.W., and form, as it were, an island in the unconformable Upper Jurassic deposits.

The Klaus beds may possibly be represented by a fine red limestone containing Crinoids, and occurring in two localities, as it yields a *Terebratula* very similar to *T. Roveredana*, Benecke. This and another red limestone, the latter containing *Aptychi*, strike from E. to W., and dip S., overlying the Dogger unconformably, but they are conformably succeeded by the white Neocomian limestone, which yields *Aptychus Didayi*, Coq. The former has afforded *Aptychus lævis*, *A. latus*, *A. gibbosus*, *A. lamellosus*, *A. crassicauda*, *Belemnites hastatus*, and *B. canaliculatus*.

[COUNT M.]

On MICROSCOPIC PLANTS *and* ANIMALS *in* ERUPTIVE ROCKS. By Dr. GUSTAV JENZSCH.

[Ueber eine mikroskopische Flora und Fauna krystallinischer Massengesteine (Eruptiongesteine), von Dr. Gustav Jenzsch. Leipsig, Engelmann, 1868.]

IN this preliminary pamphlet the author announces a remarkable discovery that he has made, namely, that various "eruptive" rocks, such as the melaphyre of Zwickau and the Thüringerwald and the porphyry of Halle, contain the microscopic remains of organisms imbedded in thin crystalline constituents, and not merely in the calcite and other materials by which spaces in the rock have been filled up. His observations were made upon cut and polished sections of the rocks, taken not from the surface (where weathering might interfere), but usually from quarries.

The organic forms detected by Dr. Jenzsch in these rocks are characteristic of standing fresh water. No Diatomaceæ have occurred to him; and of the Carapaced Infusoria, only a few *Arcellæ* have been met with. Of plants, he says that he has met with entire well-preserved Multicellular Algæ, in some of which he could even detect *the lateral extrusion of zoospores.* In the melaphyre of Zwickau these Algæ are coloured green by Delessite, and produce exactly the impression of living plants. One species, found in abundance in the milky quartz of the melaphyre of Zwickau, possesses bristle-like terminal cells, which might easily be mistaken for the spicules of *Spongilla.* The same quartz contains layers of algal cells, which are remarkably intersected by straight spaces, looking as if they had been sawn out. As the individual cells were often cut through, the author supposed that these spaces were the work of some animal; and he at last succeeded in finding an Infusorian with its extended proboscis applied to a place which had already been attacked. To this Infusorian he gives the name of *Rhynchopristes melaphyri.* With these occurred a great quantity of Rotatoria, which he refers to the neighbourhood of Schrank's genus *Limnias,* but places in a new genus, *Trikolos,* to be characterized in a larger work. Of this he distinguishes two species, *T. melaphyri* and *T. thuringiæ.*

From his observations the author infers, not that the so-called "eruptive rocks" are really sedimentary in their nature, but that these microscopic organisms actually live in the moisture permeating these eruptive rock-masses, and that they become imbedded and fossilized in a medium produced by the weathering of the rocks and infiltration of water,—in other words, that the primordial condition of the rock-masses in question has been subjected, and is still subject, to a process of metamorphism in the humid way.

[W. S. D.]

On the FLYSCH *of the* NORTHERN MARGIN *of the* CALCAREOUS ALPS *between the* LAKES *of* TRAUN *and* LAUDACH (UPPER AUSTRIA). By DR. E. MOYSISOVICS *and* DR. W. SCHLŒNBACH.

[Proceed. Imp. Geol. Instit. Vienna, June 30, 1868.]

THE succession of deposits along a north and south line from the river Traun to Traunstein is as follows:—(1) moraines, (2) terraces of glacial drift, (3) Flysch, (4) Eocene green sandstones, (5) Upper Cretaceous marls, (6) conglomerates, (7) Liassic sandstones, and (8) ancient limestones and dolomites of the Traunstein. The valley called Gschliefgraben is evidently the result of the action of water on the soft and easily decomposable shaly Cretaceous marls, which are of a light-grey or rarely reddish tint, and alternate frequently with more compact layers. These marls are very similar in petrological character to Strombeck's North-German Upper Pläner. The lower portions abound in *Inocerami, Baculites, Hamites, Scaphites,* and *Ammonites*; while Echinoderms, such as *Ananchytes, Micraster, Holaster,* &c., prevail in the upper parts. The facies is Upper Cretaceous (Pläner of Gümbel), quite distinct from that of the true Gosau strata, and bears a close resemblance to the South-Alpine "Scaglia," or to the West-Alpine "Sewer-strata." The fauna is probably a compound of those of several palæontological horizons.

The dip is at a high angle, in a southerly direction, towards the Traunstein. The soft nature and inclined position of these marls cause slips; and the effect of these local disturbances is more or less perceptible at the present time.

Olive-green qnartzose glauconitic sandstones appear to the north of the marls, abounding with *Nummulites* and other Eocene organisms. Still further north, the Grünberg is entirely composed of alternations of greyish-blue limestone containing fucoids, with Vienna sandstones which contains the characteristic vermiform markings whose nature is still undetermined.

The depression between the Grünberg and the Traunstein contains detrital matter evidently of glacial origin. It may be traced as far as the Laudach Lake, the north-eastern end of which it borders as a range of low undulating hills, evidently the remains of terminal moraines. Blocks of limestone from the Gschliefgraben lie scattered about, brought into their present position either by running water or by landslips. Moraines are also seen upon a terrace of glacial drift on the northern side of the Grünberg. The fine-grained calcareous and micaceous sandstones which are seen *in situ* on the west-south-western bank of the Lake of Laudach, between the Cretaceous marls and the Lower Lias, may possibly be concealed beneath these gravels and moraines. The sandstones in question are distinctly stratified, and dip southwards at a steep angle beneath the mass of the Traunstein. They rest immediately on, and pass into, a conglomerate composed of fragments of primitive rocks and rolled polished pebbles of white quartz, bound together by a ferruginous cement which is locally decomposed into rust-coloured matter. Organic remains are not rare, but they are usually so imperfectly preserved as not to admit of determination. The most abundant fossil is an *Ostrea*, strikingly resembling *O.* (*Gryphea*) *obliqua*; impressions of *Lima* and *Pecten* are also found. The Belemnites, which are probably derived from older rocks, have a decidedly Liassic facies. If the Belemnites are really derived from, and the Ostrea is identical with, *O. obliqua*, these conglomerates belong to the Lower Tertiaries; if this be not so, they must be placed either with the upper part of the Lower Lias or the lower division of the Middle Lias.

The calcareous sandstones above mentioned are lithologically identical with those of the upper region of the Gschlief ravine, which Mr. Stur placed in the lower division of Quenstedt's Lias β, on account of the evidence afforded by such typical fossils as *Ammonites obtusus*, Sow., *A. stellaris*, Sow., *A. oxynotus*, Quenst. (?), *Ostrea* (*Gryphea*) *obliqua*, Goldf. sp., *Pecten Hehli*, *P. textorius*, *Lima gigantea*, *Terebratula cor*, Lam., &c.

In the same ravine are found blocks of splintery, occasionally schistose, grey limestone, containing isolated dark spots similar to those of the "spotted marls," and specimens of *Ammonites margaritaceus*, thus representing the middle subdivision of the Lias.

The above facts seem to prove that an inversion of the strata has taken place between the Lakes of Traun and Laudach, as has been shown in many other localities in the Alps. The Liassic rocks seem to lie beneath the more ancient limestones and dolomites of the Traunstein; then in descending order come the Upper Cretaceous deposits; next follow the Eocene Nummulitic green sandstones, and lastly the Flysch of the Grünberg, which is unconformably overlain by the Glacial drift. The whole of the Vienna sandstone of this locality is evidently newer than the Eocene Nummulitic green sandstones, and consequently corresponds to the Flysch of the Swiss geologists. [Count M.]

On a Palm *from the* Brown-coal *of* Eibiswald, *in* Styria. By D. Stur.

[Proceed. Imp. Geol. Instit. Vienna, July 31, 1868.]

This fossil is the central portion of a large leaf. The rhachis, which is flattened by compression, bears fifteen pinnæ, but shows no trace of spines; its length is 14 inches, its breadth $\frac{1}{3}$ inch. Three other pinnæ lie on the same block in such a position as to place their former connexion with the rhachis beyond doubt. The pinnæ on the left side are preserved to a length of from 3 to 4 inches, those on the right side to a length of from 10 to 15 inches; but in all cases the apices are wanting. The distance from pinna to pinna is from $1\frac{1}{2}$ inch to 2 inches; the upper ones are alternate, and the lowest pair nearly opposite. They are linear-lanceolate in shape, the lowest pinna measuring 2 inches in its widest part. The chief nerve is prominent, with three secondary nerves on each side, of which the central one is somewhat stronger than the other and more delicate intermediate nerves. The margin of the pinna is fringed with little spines of about $\frac{1}{6}$ inch in length. The whole bears a striking resemblance to the Silhetan species *Calamus erectus*, Roxb., and may be provisionally placed in the genus *Calamus*, L., under the name *Calamus Mellingi*, n. sp., in honour of its discoverer, Mr. Melling, the Superintendent of the Eibiswald coal-mines.

[Count M.]

On the Older Brown-coal Flora *of the* Wetterau (N. W. Germany). By Prof. C. von Ettingshausen.

[Proceed. Imp. Acad. Vienna, April 30, 1868.]

There are six different localities of this flora, which contains 229 species (104 being peculiar), and represents 60 natural orders and 123 genera. The greater number of Miocene forms is met with at Münzenberg, where the Australian types prevail over the *Cupressineæ*, *Ulmaceæ*, and *Juglandeæ*. The tropical forms of the Aquitanian period are represented by the genera *Lygodium*, *Musophyllum*, *Araliophyllum*, and *Cæsalpina*.

At Salzhausen these tropical forms are mixed with a greater proportion of species characteristic of the warm temperate zone, and with some few forms of the Œningen and Lausanne deposits.

[Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Fossil Flora *of the* Tuffs *of* Czekehaza (N. Hungary). By Herr H. Wolf.

[Proceed. Imp. Geol. Instit. Vienna, August 31, 1868].

The species represented in this flora, as determined by Professor Unger, are:—

Alnus rostratum, *Ung.*
Castanea Kubinyi, *Kovacs.*
Quercus deuterogena, *Ung.*
—— Nimrodis, *Ung.*
Sapindus Erdöbenyensis, *Kov.*
Zelkowa Ungeri, *Kov.* (= Planera Ungeri).
Phragmitis Oeningensis, *Heer.*
Caulinites dubius, *Heer.*
Podogonium Knorrii, *Heer.*
—— latifolium, *Heer.*
Arundo Goepperti, *Heer.*
Carpinus grandis, *Ung.*
Juglans acuminata, *Ung.*
Rhamnus Oeningensis, *Heer.*
Andromeda tristis, *Ung.*
Banksia helvetica, *Heer.*
Populus latior rotundata, *Heer.*
Acer decipiens, *Heer.*
Ficus tiliæfolia, *Ung.*
Grewia tiliacea, *Ung.*
Sterculia tenuinervis, *Heer.*
—— Handtkeni, *Ung.*
Salix varians, *Heer.*
Lastræa dalmatica, *Ettingsh.*

In the immediate vicinity, a kind of Menilitic shale includes remains of plants and fishes, and, in beds of a tripoli-like substance, Diatomaceæ and insects. A new locality of freshwater quartz abounds in silicified stems of trees, with some few impressions of leaves and minute shells of terrestrial Mollusca. [Count M.]

On the Geology *of* Texas. By Herr A. R. Roessler.

[Proceed. Imp. Geol. Instit. May 31, 1868.]

The territory of Texas offers a complete series of deposits from the Palæozoic Potsdam Sandstone up to the highest Tertiaries. A bed of genuine bituminous coal is known to exist near Fort Belknap. The Carboniferous formation has been stated to extend over 5000 square miles of surface, and to be 350 feet in thickness. The thickness of the Cretaceous deposits probably exceeds 1500 feet; they are distinctly stratified, generally fossiliferous, coralline limestones, particularly well developed in the

Comanche-summit (Johnson County), 650 feet above the level of the Rio Brazos, where they appear under the form of white hippurite limestones, overlying a bed of grey limestones, whose strata extend about 70 yards westward and form a low slope; they are filled to the depth of 30 feet with *Exogyra Texana, Holaster simplex, Lima Wacoënsis,* and other organic remains. They alternate frequently with accumulations of *Gryphœa Pitcheri* and *Exogyra Texana,* and the total thickness of this group is 75 feet. On the south side of the hill, the Gryphæa-beds are 200 feet thick. The upper portions of the hill include a small quantity of *Exogyra Texana, Janira occidentalis, Lima Wacoënsis, Holaster simplex,* and a *Toxaster.* The limestones above these strata abound in Hippurites, *Caprotinæ,* &c. The Texan Tertiaries consist of sandstones and limestones, the former frequently impregnated with a large proportion of oxide of iron. Remains of *Zeuglodon cetoides* have been found in the hill-range of the Rio Colorado, and bones of *Mastodon giganteus* and *Elephas primigenius* and other large quadrupeds on the banks of the Rio Brazos.

The calcareous sandstones and dolomitic limestones of the Potsdam period are of frequent occurrence in the western region of the State. They are rich in silica, and furnish marbles of superior quality.

The Azoic rocks include extensive beds of magnetic iron-ore. Enormous loose masses of this ore are spread over the surface about Johnson's Creek (Llano County); a hill, rising 45 feet above the level of the River Llano, is one solid mass of iron-ore; its extension in depth is still unknown. The ores, very analogous to those of the Iron Mountain of Missouri, are partly magnetic, partly specular oxide of iron; they contain on an average 96·890 per cent. of per- and protoxide of iron, with 2·818 per cent. of insoluble siliceous substances, and give 74·93 per cent. of metallic iron. This iron region is surrounded on all sides by ridges of granite, intersected by veins of quartz and associated with red felspar, gneiss, talc, and chloritic slates. Wood abounds in the environs, and limestone and steatite may be easily procured in abundance, the extreme indolence of the inhabitants, who find an easy and profitable employment in breeding cattle, sheep, and horses, being the only obstacle to the establishment of extensive iron-works.

Superficial indications of the existence of great quantities of petroleum below the surface are not unfrequent in the environs of the "Four Lakes" (Harding County). The acidulated waters of the lakes, and those of the springs surrounding them, are impregnated with carburetted hydrogen gas and petroleum. This locality belongs to the Miocene period, forming a zone 50–75 miles in breadth and extending several hundred miles in length along the coast. Mr. Roessler has brought from the sources of the Rio Brazos a block of meteoric iron weighing 315 lbs. [COUNT M.]

On the Cliff-Limestones (Klippenkalk) *of the* Northern Carpathian Range. By Dr. G. Stache *and* Dr. M. Neumayr.

[Proceed. Imp. Geol. Instit. Vienna, August 31, 1868.]

Evident and extensive foldings of strata have been observed in the Pieniny mountain-group, which is essentially composed of Jurassic limestones and Neocomian variegated marls and limestones, as also in the cliffs of Middle and Upper Jurassic limestones north-west of Lublau. The inferior Crinoidal limestones (Dogger) are steeply over-vaulted by the red limestone strata of Czorstyn. Between Szczawnica and the valley of Lipnik, even compact older Tertiary strata, which may be supposed to offer more constant resistance to destruction and decomposition (Nummulitic limestones and Eocene conglomerates with calcareo-dolomitic cement), show the outlines of cliffs rising from amidst red and grey Neocomian marls, Eocene nummulitic sandstones, and loose conglomerates. Several eruptions of a trachyte with sanidine, oligoclase, and amphibole amidst the cliff-region are met with near Szczawnica, proving that the action of the grand trachytic eruptions between Tokaj and Eperies (North Hungary) extended in the direction of the cliff-range and beneath the Carpathian sandstones running parallel to it. These facts lead to the following conclusions:—*These cliffs are the remains of a system of complicatedly folded hard and resisting strata. This folding was caused by the powerful pressure of a great eruption, which, in its progress beneath the range of Carpathian sandstones, found no issue upwards, and affected the whole of the older deposits then accumulated between its chief line of upheaval and the compact granitic mass of the Tatra.* A final upheaval of this mass may have coincided with this trachytic eruption at the beginning of the Neogene period. The softer materials overlying the more compact calcareous strata have been partly destroyed in the course of the catastrophe. The Carpathian sandstones and older Tertiary sandstones and marl-shales which are conspicuously developed along the northern and southern limits of the cliff-region appear generally in but slight development close to the limit of the red, grey, and variegated inferior Cretaceous marls from among which the cliff-ranges rise. A general destruction and removal by water of the deposits above the Neocomians is not admissible, except on the supposition that this range was repeatedly and for a long time, during the Cretaceous and Tertiary periods, the coast-limit of a continental region. Under the circumstances just described, a powerful trachytic eruption must necessarily have given rise to uncommonly frequent and diversified derangements and foldings of the whole system of strata. In some places broken or burst portions of the inferior more compact limestone beds have pierced through the softer deposits above them, while these last have been compressed between the foldings and the fissures of the more resistant calcareous materials. The red Crinoidal limestones contain *Ammonites recte-lobatus, Terebratula curviconcha*, and some other species from the Klaus-strata (Bathonian), together with *Ammonites alternans*, v. Buch, and several other forms peculiar to strata of less remote age. In one place near Lublau forms from the Klaus-strata are found exclusively characterizing the lowermost beds of the red Crinoidal limestone next to the white limestone. The dark-red nodular limestones of Czorstyn include in their upper horizon a fauna similar to that of the *Acanthicus*-strata, and in their inferior one *Terebratula diphya* and genuine Tithonian Ammonites. The species found in them are:—

Ammonites compsus, *Opp.*	Ammonites isotypus, *Ben.*
**—— iphicerus, *Opp.*	*—— quadrisulcatus, *d' Orb.*
—— torti-sulcatus, *d' Orb.*	—— montanus, *Opp.*
*—— Kochi, *Opp.*	—— Achilles, *d' Orb.*
*—— Calypso, *d' Orb.*	—— hoplizus, *Opp.*
**—— Ruppelensis, *d' Orb.*	Aptychus lamellosus.
**—— Oegir, *Opp.*	Echinoderms.

The species marked * are Tithonian ones, those marked ** are characteristic of *Acanthicus*-strata. The Rogoznik strata include numerous Brachiopods, among which are *Terebratula diphya*, Col., of unusual size, and *T. Bouéi*, Zeuschn., together with various Cephalopods, such as *Ammonites carachtheis*, Zeuschn., *A. incultus*, Opp. (non Beyrich), *A. rasilis*, Opp., *A. Rogoznicensis*, Zeuschn., *A. Stasiczi*, Zeuschn., and an undoubtedly Tithonian flexuose form standing next to *A. compsus*. Further west clear flesh-coloured limestones with *A. semisulcatus*, d'Orb., *A. Calypso*, d'Orb., *A. senex*, Opp., &c., appear as the probable equivalents of the genuine Rogoznik breccias. The limestones of Czorstyn include *A. acanthicus*, several other forms of the subdivisions *Fimbriati* and *Planulati*, and a probably new species, flattened, much involute, with a broad triangular back, and its sides adorned with a great number of sharp, much curved, and frequently dichotomizing ribs. The presence of *A. alternans* in the red Crinoidal limestone seems to indicate this deposit to be equivalent to the Bath, Kelloway, and lowermost Oxford strata. [Count M.]

Marine Shells *found in the* Sands *of the* Desert *of the* Kara-kum. By G. von Helmersen.

[Proceed. Imp. Acad. St. Petersburg, March 5, 1868.]

The sand investigated by the author contained well-preserved specimens of *Cardium edule* and *Dreissena polymorpha*, both of which still live in the Aral and Caspian Seas. The shells, especially those of *Dreissena*, are remarkable for their small size. The occurrence of these shells near Ssapak, from which place part of the sand was brought, indicates the former extension of the Aral Sea to a distance of 30 wersts to the east of its present limits; and the author expresses his belief that the entire country from the Aral to the lakes Telekulj-Ata and Karakulj, and beyond these up the River Tschu to the sandy deserts of Majun-kum and Akkum, is an old sea-bottom. [W. S. D.]

On the Lavas *of* Vesuvius. By Professor Fuchs.

[Proceed. Nat. Hist. and Med. Soc. Heidelberg, January 22, 1869.]

The author states that the chemical composition of the Vesuvian lavas is nearly the same from the oldest to the most recent. Soda is the only very variable constituent; it ranges from $1\frac{1}{2}$ to 5 per cent. This variation is due to secondary chemical processes taking place before the outpouring of the lava. The three most essential mineral constituents are leuzite, augite, and magnetic iron. With these are associated, but often only in small quantities or in particular lavas, olivine, mica, hornblende, garnet, sodalith, felspar (triclinic and sanidine), nepheline, and apatite. Only a small portion of the leuzite is in well-developed crystals, an indication that after its formation it was partially altered by the high temperature of the surrounding lava mass. Similar alterations appear to have been produced in a great part of the constituent minerals of the lava. The lava, containing both crystalline and amorphous mineral substances, must have consisted at the time of its outflow of a fused mass in which crystals and fragments of crystals swam. The author has repeated and extended the investigations of Forchhammer and Rogers upon the action of hot water under strong pressure upon the silicates of which the lava is composed. This action is particularly energetic when the water contains carbonic, hydrosulphuric, sulphurous, or hydrochloric acid; and it is to it that the author attributes the changes produced in the chemical constitution of the lava. [W. S. D.]

Mollusca *of the* Upper Tertiaries *of the* Vicentine. By Herr T. Fuchs.

[Proceed. Imp. Acad. Vienna, July 23, 1868.]

The whole number of species recorded by the author is 214 (among which 71 are new), distributed as follows through the stratigraphical subdivisions:—Castel' Gomberto strata 118, Laverda strata 12, Sangonini strata 119. Of these 214 species, 128 are known to occur in other localities, viz. 70 in the Inferior Eocene (Sables inférieurs, Calcaire grossier, Sables moyens, Barton Clay, and their equivalents), 91 in the Upper Eocene (Oligocene). Only 24 species are common to the upper and inferior Vicentine Tertiaries, from which last about 300 species are known, so that the limit between the upper and inferior deposits is far more distinctly traced than it is, for example, in the Hampshire basin, where, according to Prof. von Koenen, 22 species, identical with those of the Barton Clay, are met with among the 54 species of the Oligocene Fauna of Brockenhurst. There is *not one single species* among the 300 just mentioned which is, at present, known to occur exclusively in the Upper Eocenes. No trace is found at Ronca of the comparatively far more recent species erroneously ascribed to this locality, but in reality imbedded in Castel' Gomberto strata or in the basaltic tuffs of Sangonini, while Ronca offers many new forms associated with a surprising abundance of beautiful Calcaire grossier forms. In consequence, the strata of Castel' Gomberto, Laverda, and Sangonini may safely be ranked in the group now generally named "Oligocene," although, with regard to the geological constitution of the Alpine region, the denomination of "Upper Eocene" may be preferred. The fauna of Gomberto offers the most striking analogies with the fauna of the blue marls of Gaas and Lesbarritz; it contains an abundance of large species of *Strombus, Cassis,* and *Natica*; *Cerithia* and *Trochidæ* are, however, predominant. The fauna of Laverda, especially of the marls, includes some few species of Sinupalliate Bivalves, and is completely concordant with those of Oberburg (Styria) and Polschiza (Carniolia).

The basaltic tuffs of Sangonini, near Lugo, abound in Canaliferous Gasteropods, especially of the genera *Fusus, Pleurotoma, Murex,* and *Tritonium*: their fauna is strikingly analogous to the Eocene fauna of England; 20 species of it are common to the Inferior Oligocene fauna of N. Germany (Latdorf, Unseburg, Wolonirsleben, Helmstädt, &c.). The molluscan Upper-Eocene fauna of the Vicentine shows a remarkably *tropical* type, especially in the Gomberto strata, in this respect contrasting with the equivalent deposits of North Germany.

[Count M.]

On the Jurassic *and* Cretaceous Deposits *of the* Central Apennines. By Dr. C. A. Zittel.

[Proceed. Imp. Geol. Inst. December 15, 1868.]

The Tithonian and Lias group are particularly well developed. The Roman Apennines show important Inferior Cretaceous beds, but only scanty traces of Jurassics ("Dogger"). The succession of horizons is as follows in *ascending* order:—

1. *Inferior Lias.* Large masses of white limestones, with no organic remains except, in some few localities, imperfectly preserved Brachiopods, Gasteropods, and *Avicula janus*, Menegh.
2. *Middle Lias.* Light-coloured stratified limestones, with a great variety of organic remains (most of them new species), such as *Ammonites Davœi, A. Ragazonii, A. Algovianus, A. Lavinianus,* abundant Brachiopods, stems of Crinoids, &c.
3. *Upper Lias,* with abundance of *Ammonites bifrons, A. Comensis, A. serpentinus, A. radians,* &c., *Phylloceras heterophyllum, P. Nilssoni, Terebratula Erbaënsis,* and *T. Rozzoana.*
4. *Inferior Dogger.* Yellowish marly limestones, with *Ammonites fallax, A. scissus, A. Murchisonæ,* and *Phylloceras ultramontanum.*
5. *Aptychian Shales,* with *Aptychus punctatus* and *A. latus.*
6. *Tithonian horizon.* Light-coloured marble-like limestones, with abundant Cephalopods, generally identical in species with those of Rogoznik in Galicia and of South Tyrol.
7. *Neocomian white limestones,* with *Ammonites incertus, Phylloceras infundibulum,* &c.
8. *Rose-coloured limestones,* with Fucoidal shales in their lowermost horizon.
9. *Scaglia,* as in S. Tyrol.

[Count M.]

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OF

GEOLOGICAL MEMOIRS.

On the CRETACEOUS FLORA *of* MOLETEIN, MORAVIA. By DR. O. HEER.

[Proceed. Imp. Geol. Instit. Vienna, April 21, 1868.]

EIGHTEEN species have been determined from these beds, namely, one Fern, *Gleichenia Quenstedti*, Heer; one Palm, *Palmacites horridus* Heer (petiole only); four Abieteæ, *Sequoia Reichenbachi*, Gein., sp.; *S. fastigiata*, Sternb., sp.; *Cunninghamites elegans*, Corda, and *Pinus Quenstedti*, Heer; two Moreæ, *Ficus Mohliana*, Heer, and *F. Krausiana*, Heer; one doubtful Polygonean, *Credneria macrophylla*, Heer; two Laurineæ, *Daphnophyllum Fraasi* and *D. crassinervium*, Heer. The other species are *Aralia formosa*, Heer; *Chondrophyllum grandi-dentatum*, Ung., sp.; *Magnolia speciosa*, Heer; *M. amplifolia*, Heer; *Myrtophyllum* (*Eucalyptus*?) *Geinitzii*, Heer; *M. Schübleri*, Heer, and *Juglans crassipes*, Heer. This flora is remarkable from being the earliest in which Dicotyledonous plants are conspicuously represented; two-thirds of the species belong to this class, which is not represented in the Wealden, and but sparingly in the Gault and Neocomian. The families to which these species belong are in no way related to the Lower Cretaceous flora of Europe generally; among them the Magnolias and Myrtles hold a high position in the vegetable scale. The fossil plants of Moletein are in an excellent state of preservation, and the leaves are of large size, although it might have been expected that the Dicotyledons next following the Coniferæ in time would be small-leaved forms. [COUNT M.]

On the FOSSIL FLORA *of the* ARCTIC REGIONS, *by* DR. O. HEER.

[Proceed. Imp. Geol. Instit. Vienna, April 21, 1868.]

PROF. HEER has just published a description of this flora illustrated by fifty plates, Dr. Ch. Cramer, of Zurich, contributing the description of the fossil woods. The Carboniferous flora is represented only on Melville Island *; the Cretaceous only in North Greenland. Miocene deposits with vegetable remains exist in North Greenland (with fossil insects), Banks' Land, Mackenzie, Iceland, and Spitz-

* The Swedish expedition of last year detected Carboniferous strata both in Bear Island and in Spitzbergen, and in the latter fossil remains of animals of Triassic and Jurassic forms.

bergen. The Carboniferous flora numbers 12 species, the Cretaceous 14 species, some of which are identical with those in European strata. The Miocene flora numbers 162 species, of which 112 are new, while very few are referable to forms actually living in those regions. Central and South European, Japanese, and especially Asiatic and American types are found. *Taxodium dubium, Sequoia Langsdorfii, Alnus Kefersteini, Fagus Deucalionis,* and *Platanus aceroides,* are the prevailing forms. Palms, fine-leaved *Leguminosæ,* and *Cinnamomum* are absent. It may be concluded from the general character of this flora that the mean annual temperature of the Arctic regions was not lower than 48° Fahr.

The deposits of this period are in these regions intimately connected with the eruptive rocks and their tuffs. The sandstones, with large plates of mica, in Greenland and Iceland, and their yellowish-white tuffs, call to mind the tuffs of Gleichenberg, and other German trachytic and rhyolitic tuffs in which Palms do not occur. Several Arctic forms, as *Sequoia Langsdorffi, Phragmites Œningensis, Salix macrophylla, Betula prisca, Fagus Deucalionis, Planera Ungeri* and *Platanus aceroides* are characteristic of the Congerian and Sarmatian strata. A petiolate *Proteacean* leaf mentioned by Mr. D. Stur as allied to *Hakea Erdöbenjensis,* a Hungarian Miocene species, may possibly be referable to *MacClintockia Lyelli.* The lower beds of the Vienna and Hungarian basins include few eruptive rocks and tuffs, but they are everywhere connected with strata containing the remains of Palms. The entire absence of Palms from the Arctic and European Sarmatian tuffs is far from being certain, and until the presence of *Castanea Kubinyi* and *Parrotia pristina* in the Polar regions has been established, no comparison can be made between the Arctic tuffs and those of the Sarmatian horizon. Possibly, sedimentary rocks of older date than the Miocene may be completely absent from the Polar regions, as they are in the grand valley of Hungary. This supposition admitted, the American and European floras may have been connected during the older Miocene period without the intervention of a hypothetical Atlantis.

[COUNT M.]

On the GEOLOGY *of the* ALTAÏ MOUNTAINS.

By Prof. BERNHARD VON COTTA.

[Proc. Imp. Geol. Institute, Vienna, March 2, 1869.]

PROFESSOR COTTA, who visited the Altaï group during the summer of 1868, at the request of the Russian Government, with the special object of investigating the metalliferous deposits of those mountains, gives the following account of their geology. The principal rocks of the Altaï are:—

1. Crystalline slates.
2. Silurian slates.
3. Devonian limestone.
4. Carboniferous limestones, shales, and sandstones.

5. Granites.
6. Euritic porphyries.
7. Metalliferous deposits.
8. Greenstones.
9. Diluvial deposits.
10. Recent deposits.

The absence of the entire series of sedimentary rocks between the Dyas and the Diluvium leads to the conclusion that during the whole of this long period the region of the Altaï was dry land, and that during the Diluvial period it was covered with water as far as the foot of the mountains. At this time an ocean, extending from the Glacial sea to the Ural, the Altaï, and the Caspian and Black Seas, seems to have formed a boundary between Europe and the south and east of Asia. The absence of traces of glaciers, and, indeed, generally, of any vestiges of a glacial period, such as are so frequently observed in Europe, may be accounted for by the supposition that a current of warm sea-water, passing from the Mediterranean to the Glacial sea, took its course along the then existing Altaïc coast. The Mammoths, remains of which have been found in some of the caves of the Altaï, may have lived upon large flat islands rising out of the Diluvial sea. This sea having been removed, either by the upheaval of the land or by the draining off of its waters, left behind it numerous lakes, some of which still consist of salt water, and the climate acquired its present continental type. No traces of Tertiary, or Post-tertiary eruptions have been met with. The most recent eruptive rocks are Greenstones, which have broken through all the deposits, up to the metalliferous. Everywhere the old sedimentary strata are considerably upheaved and disturbed, but the periods at which these upheavals took place cannot at present be ascertained.

The metalliferous deposits in the west Altaï are essentially uniform in type. They consist of sulphate of baryta or quartz, with a great diversity of metallic sulphurets, the products of the decomposition of which usually occupy the higher levels. The form of these deposits is very irregular, and they probably owe their origin to the filling up of fissures. They occur especially in the crystalline and sedimentary slates, and also in porphyry, but never in granite or greenstone; indeed, the last-mentioned rock has broken through a number of them. The metalliferous deposits of the low mountain-chain of Salair, in which granite is almost entirely deficient, form irregular beds in a talcose slate, but are evidently of later date than the rock in which they are imbedded. Sulphate of baryta predominates among their constituents. [Count M.]

On Chelonia *from* Eibiswald, *in* Styria.
By Prof. C. Peters.

[Proc. Imp. Geol. Institute, Vienna, April 6, 1869.]

Professor Peters compares his new genus *Chelydropsis*, from Eibiswald, with the Jurassic Chelonians from Soleure ("Etage Strombien"), Kehlheim (Solenhofen), and Hanover (Kimmeridge). Those from Kehlheim were described, under the name of *Platychelys Oberndorferi*, in 1853, by Prof. A. Wagner, and by H. von Meyer in 1860. Other similar forms from the Swiss Jurassic deposits, and from the English Wealden and Purbeck strata, described by M. Pictet and by Prof. Owen, prove that the series of Chelydroid Chelonians, characterized by the peculiar structure of their marginal plates, persisted from the Jurassic to the Tertiary period. Prof. Rütimeyer showed (1868) the close analogies existing between the living *Chelydra serpentina* and *Platychelys Oberndorferi*, and also such fossil forms as *C. Murchisoni*, H. von Meyer, from Œningen, *C. Decheni*, H. von Meyer, from the Rhenish laminated coal, and the incomplete remains from Eibiswald described by Prof. Peters (1850) as "*Chelydra*, sp." These analogies are especially evident in the dorsal carapace, which has served for the establishment of the genus *Chelydropsis*. Its double row of marginal plates, such as at present occurs only in the American *Chelonura Temmincki*, Holbr., exactly reproduces the type of the above-mentioned Jurassic forms, and would probably be still more conspicuous in young individuals. The Hanoverian fossil forms lately described by Dr. Maak in his great work on the systematic arrangement of the Chelonia, exhibit the same type, although less distinctly, and also present remarkable instances of the combination of osteological types which have been completed and differentiated in subsequent periods. The family of the Chelydrians thus presents a continuous series of osteological transformations, the origin of which has been traced by Professor Rütimeyer in young individuals of *Chelydra* and *Platychelys*. [COUNT M.]

The BRYOZOA *of the* TERTIARY DEPOSITS *of* KISCHENEW, *in* BESSARABIA. By Prof. REUSS.

[Proc. Imp. Acad. Vienna, June 17, 1869.]

THESE deposits belong to the Sarmatian stage, the remains of Bryozoa from which have been but little studied. In the Vienna basin they are rare and indistinct, but several species have been obtained from Hungary and Transsylvania. The rock at Kischenew, a limestone consisting chiefly of shells cemented together, contains many specimens of Bryozoa, which, however, are more abundant in individuals than in species. The author recognizes only four species, namely:—*Tubulipora conferta*, *Lepralia verruculosa*, sp. n., *Hemieschara variabilis*, and *Diastopora corrugata*. The last two species present much diversity of form, which has misled Eichwald, who, in his 'Lethæa Rossica,' describes *Hemieschara variabilis* under the names of *Cellepora syrinx*, *C. tinealis*, *Vincularia teres*, and *V. tristoma*; and *Diastopora corrugata* as *Pustulopora primigenia*, *fruticosa*, and *curta*. [W. S. D.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

The Echinoida *of the* Upper Tertiaries *of* Austria *and* Hungary. By Dr. G. C. Laube.

[Imp. Geol. Institute, Vienna, June 30, 1869.]

In a memoir on this subject, prepared for publication in the 'Abhandlungen' of the Imperial Geological Institute of Vienna, Dr. Laube describes the following fossil Echinoida from the Upper Tertiaries of Austria and Hungary:—

Cidaris Schwabenaui, sp. n. Long, rod-like spines, with granular spinules directed forwards in narrow parallel rows. Vienna basin.

Psammechinus Serresii (Desmoul. sp.). Vienna and Hungary.

—— *mirabilis* (Nicol. sp.), Vienna basin.

—— *monilis* (Desmar. sp.), Vienna basin.

—— *Duciei* (Wright), Vienna basin.

Echinus dux, sp. n. Flattened, with ten rows of warts in the interambulacral and four in the ambulacral areas. Vienna basin.

—— *hungaricus*, sp. n. Large, hemispherical warts of equal size in the ambulacral and interambulacral areas, ten rows in the latter and four in the former. Hungary.

Echinocyamus transylvanicus, sp. n. Small, differing from *E. ovatus* (Goldf. sp.) by its more pointed summit and more regular petaloidal star.

Amphiope perspicillata (Ag.) and *A. elliptica* (Desor). Vienna basin.

Scutella vindobonensis, sp. n. Large, with a sharply angular, prominent rostrum, and peculiarly inflated between the posterior petaloidia. Vienna basin and Hungary.

Clypeaster scillæ (Desmoul.), *C. crassicostatus* (Ag.), *C. portentosus* (Desmoul.), Hungary; *C. acuminatus* (Desor), Vienna basin and Hungary; *C. gibbosus* (Risso), *C. pyramidalis* (Michel.), *C. partschi* (Michel.), *C. intermedius* (Desmoul.), and *C. latirostris* (Ag.), Vienna basin.

Echinolampas hemisphæricus (Lamk. sp.), vars. *Linkii* (Goldf.) and *rhodensis* (Laube), the latter distinguished by its smaller size and less oval form. Vienna basin and Hungary.

—— *Laurillardi* (Ag.). Vienna basin and Hungary.

—— *angustistellatus*, sp. n. Nearly circular, slightly produced behind; petaloidia narrow, highly arched. Vienna basin.

Conoclypus plagiosomus (Ag.). Vienna basin.

Pericosmus affinis, sp. n. Very like *P. latus* (Desor), but with a narrower frontal furrow and shorter posterior petaloidia. Vienna basin.

Hemiaster rotundus, sp. n. Like *H. acuminatus* (Münst.), but of a more rounded form, and with the anterior declivity steeper. Vienna basin.

—— *kalkburgensis*, sp. n. Like *H. acuminatus* (Münst.), but with the petaloidia different and the frontal furrow longer and narrow; more cordiform than *H. rotundus*. Vienna basin.

Schizaster leithanus, sp. n. Large, cordate, vertex very excentric, frontal furrow long and deep.

—— *Parkinsoni* (Defr.). Vienna basin.

—— *Karreri*, sp. n. Of moderate size, ovate, deeply emarginate in front; distinguished from *S. Parkinsoni* by its more excentric vertex and straight petaloidia. Hungary.

—— *scillæ* (Desmoul.). Baden.

—— *Desori* (Wright). Vienna basin.

——, sp. Upper Austria.

Brissomorpha, g. n. Intermediate between *Brissus* and *Prenaster*, differing from the former in the shape of the petaloidia and front, from the latter in size and covering.

—— *Fuchsi*, sp. n. Vienna basin.

Spatangus euglyphus (Laube). Vienna basin.

—— *austriacus*, sp. n. Large; differing from *S. reginæ* (Forbes) by its broader petaloidia and several spinose warts placed in zigzag between the petaloidia; and from *S. pustulosus* (Wright) by its deeper frontal furrow and its more rounded form.

[Count M.]

On the Lavas *of* Mount Vesuvius. By Herr H. Wolf.

[Proc. Imp. Geol. Institute, Vienna, February 16, 1869.]

These lavas, according to the author, are all Leucite-porphyries of a homogeneous, slag-like, porous, and nearly pumicose structure. Their fundamental constituent is a greenish vitreous substance, containing microscopic crystals of Plagioclase, Sanidine, and Leucite,—the last predominating both as to size and quantity. Pyroxene and magnetic protoxide of iron have also been observed. Small plates of magnesian mica occur very rarely. [Count M.]

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On the SUCCESSION *of the* UPPER TRIASSIC, RHÆTIC, *and* OLDER LIASSIC DEPOSITS *near* HOMMONA *in* NORTH HUNGARY. By M. PAUL.

[Proc. Imp. Geol. Institute, Vienna, 31st July, 1869.]

The succession of these deposits in descending order is as follows:—

White-veined Limestones, occasionally dolomitic, constantly associated with layers of quartz.
Grey Marly Shales, alternating with compact Limestone-beds, containing Pentacrinites, *Lima* (?), and other indistinct organic remains (24–28 feet).
Limestone with *Plicatula intus-striata, Ostrea Haidingeriana, Pecten,* &c. (6–12 feet).
Limestone, with large Megalodon sections (3–4 feet).
Limestone, with *Terebratula gregaria* (6–12 feet).
Dolomitic Marl (3 feet).
Limestone, with *Lithodendra* (9 feet).
Limestone, with abundance of *Terebratula gregaria*, which is associated in the deeper nodular layers with Cephalopods and Gasteropods (24–30 feet).
Marly Limestones, with *Plicatula intus-striata, Ostrea Haidingeriana* and *Pecten* (6 feet).
Soft dark Shales (3 feet).
Dolomitic Marls, more compact (3 feet).
Soft Marls, alternating with more compact beds (3 feet).
Dark red, very crumbly Marl-shales (12–18 feet).
Quartzite and coarse Quartz-sandstone, very like that occurring in the Lias (30–36 feet).
Dark Shales, with distinct, compact beds, which are sometimes quartzitoid (36–48 feet).
Variegated Marls in thin layers, somewhat dolomitic (120–180 feet).
? Dolomitic Breccia.

The white-veined Limestones are overlain by Dolomites containing *Belemnites*, and these by Limestones with hornstone and traces of Crinoidal Limestone, which may represent the superior Jurassic deposits.

This section proves that the white-veined Limestone, so widely spread in the Carpathians, and generally referred to the Trias, belongs, with its subordinate Dolomites and Quartzite-beds, to the Lias. It is not, however, the lowest stage of that formation, as is proved by the Quartzites of the Little Carpathians, between which and the Kössen beds a great deposit of dark-coloured Limestone is intercalated. This section reveals another fact of interest with regard to the Kössen beds, namely, that Bivalves and Brachiopods may alternately predominate repeatedly, so that they do not stand to each other in the relation of constant stratigraphical horizons.

[COUNT M.]

Algæ *enclosed in* Diamonds. By Dr. Göppert.

[Abhandl. Schles. Ges. für vaterl. Cultur, 1868.]

The author was led by his observations upon bodies enclosed in diamonds to conclude that they are of Neptunian origin, and he considers that this opinion is supported by the fact that the primary clay-slate and gneiss in which diamonds are found are now known to contain organic remains. He notices especially *Eozoon canadense*, the organic particles found by H. Rose in smoky topaz, the *Oldhamiæ* of Forbes, and the occurrence of nitrogen and organic material in many minerals, as demonstrated by Delesse. The author now described a diamond containing dendrites, such as occur in chalcedony, jasper, and other minerals of aqueous origin. Another, weighing 263 milligrms., in the Berlin Museum, contains a quantity of round, uniformly green corpuscles, precisely resembling those of *Protococcus pluvialis* in size and form. A third specimen, weighing 345 milligrms., and also belonging to the Berlin Museum, contains a quantity of green corpuscles of a more elongated form, often adhering together in the form of a chain. These most closely resemble the living *Palmoglœa macrococca.* The author describes these forms as Algæ, under the names of *Protococcus adamantinus* and *Palmoglœites adamantinus.* (From the Report of the Imp. Geol. Institute, Vienna, August 31, 1869).

[W. S. D.]

The Trias *in* Spitzbergen. By Dr. G. C. Laube.

[Proc. Imp. Geol. Institute, Vienna, 31st July, 1869.]

Professor Nordenskiöld has lately brought a great quantity of Triassic fossils from Spitzbergen to Stockholm. The partially bituminous shales, to which the author gives the name of "*Halobia*-shales," present a striking resemblance to the Alpine "Wengen shales;" and above these are strata containing Cephalopods very like those of the St.-Cassian beds. *Nautilus Nordenskioldi* (Lindstrom) exactly resembles a *Nautilus* from the Hallstatt limestone. *Nautilus trochleæformis* is an *Arcestes* closely approaching *A. cymbiformis*; *Ammonites Gaytani* is also an *Arcestes*, approaching *A. Barrandei* (Laube). *Ceratites Blomstrandi* is exactly like *A. Wengensis* (Klp.). Brown strata, supposed by Prof. Nordenskiöld to be Jurassic, contain *Halobiæ*, and also two small Gasteropods, a *Chemnitzia* and a *Loxonema*, both undoubtedly having the character of St.-Cassian species. Among the specimens sent are fragments of black shales from the Ice-fjord, with numerous impressions of *Halobia Lommali* (Wissm.), which cannot be distinguished from the true "Wengen shales;" the fragments from Cape Thordsen, containing *Halobia rugosa* (Gümb.)=*H. Haueri* (Stur) and a much compressed Ammonite (*A. floridus*?), present an equal resemblance to Stur's "Reingraben shales."

[Count M.]